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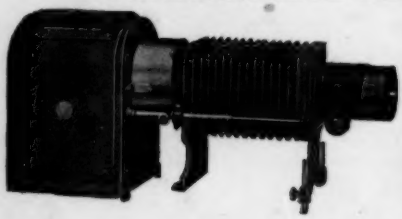

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVIII, No. 5 MAY, 1918 WHOLE No. 151

PROGRESSIVE TEACHING OF MATHEMATICS—WHAT IS IT ?

By G. W. MYERS,

University of Chicago.

Members of the Club: If I were a sufficiently staunch republican in politics, as I used to be, I would not admire the adjective in my title. I presume I should prefer the phrasing "stand-pat" mathematical teaching. But nowadays I am not sufficiently staunch. If I were sufficiently "dyed-in-the-wool" democratic, perhaps I should prefer "Reform" mathematical teaching. But I am not sufficiently partisan even at this angle of bias. Furthermore, I shall assume that there is amongst you a sufficient degree of political detachment to tolerate the adjective, progressive, as a qualifier of mathematical teaching.

What shall a mathematical teacher do today to merit being regarded as a progressive teacher by his professional colleagues? In this day of school surveyors, gap-bridgers, critics, iconoclasts, and general fault-finders, when to the staid educationist it looks as though the experts were running amuck through the educational world in general, and through mathematical education in particular, it is not easy to answer this question well. The answer, however, is none the less desirable, and I shall at least try to give my form of answer.

THE ATTITUDE OF THE PROFESSIONAL TEACHER.

In the first place, what one should do to be regarded as a progressive mathematical teacher must depend on the nature of the situation in which he has contracted to teach. If one must teach under a rigid curriculum, fixed by the authorities beyond the pale of redemptive activities, he should neither chafe nor quail, but calmly accept the inevitable. The progressive teacher in such a situation, and this type of situation is numerous, will rather direct his efforts at making the very best

[1]Talk to the City Mathematical Club on Friday evening, January 11, 1918.

he can out of the existing order than waste them in trying to remedy the irremediable. He will do best by following the conventional procedure. But even here he may avail himself of the pedagogic fact that we spend too large a proportion of our time and effort in merely exemplifying and illustrating mathematical principles and too small a proportion in teaching how to solve social and everyday problems with the aid of the mathematical tools. Even in such a situation I would enrich the work with more applications in which the toolage advantages of the school mathematics would become apparent. This much may be attempted by even the timid teacher without jeopardizing his position.

If the fixed curriculum were distinctly poor, I should now and again hint of ways in which it might be made better. I would, however, be careful to let the principal or superintendent have the first chance at the honor of doing the improving, and would undertake it myself only on the request of this usually jealous official. Of course, the main reason that mathematical teachers have influenced mathematical curricula so slightly is that they have been allowed so little opportunity to influence it. But when educational people go about saying that the mathematical specialist has had his day with the curriculum, has failed to profit by it, and that now the improvement of mathematical courses should be turned over to others, it is well to remember that "his day" was usually usurped by some "superior official." In the fixed situation, the progressive teacher of mathematics will strive to be "as wise as a serpent and as harmless as a dove."

There are, however, numerous situations in which a level-headed mathematical teacher can do about as nearly as he pleases with the mathematical course of study and the special courses that make it up, as a single member of a necessarily correlated corps of teachers ought to want to do. The kind of use the favored members of our profession who function in such situations make of their opportunities is of the very highest significance for the improvement of our work. It is they to whom we are to look for the first formulations of general plans for new advances and for the smoothing out of the first steps in bringing the new formulations into practicable shape for average conditions. The progressive teacher whose good fortune has placed him in one of these favored situations will today give close attention to the following points:

I. He will see to it that his attitude toward attacks from

professional critics upon his subject and upon the results of his work as teacher is professionally correct. Attitude in mathematical matters means much more than many people think. For example, no clearer basis for differentiating the separate fields of arithmetic and algebra has yet been offered than that of attitude toward problems. If the attitude is to find the solution of this particular problem, the problem is one of arithmetic. If it is to find the solution of this type, or class, of problem, we have an algebraic problem. Right attitude implies the correct position for an economical start. "Well begun is half done" is more than an adage in mathematical matters. But the particular phase of attitude I am here emphasizing is attitude toward attack. It is no secret that we are being vigorously attacked nowadays both as to subject-matter and methods.

Of the attitudes that have found spokesmen from one quarter or another the following four are prominently in evidence:

1. The neutral attitude.

This attitude expresses itself in such phrases as, "Mathematics is good enough. Let it alone." "If you ask us, 'What are we going to do about it,' we answer, 'Nothing.'" "What was good enough for grandfather, is good enough for us." Their counsel is: "Go into the cyclone cellar and wait for the storm to pass." In spite of some very disturbing facts against the adequacy of the results and the time and effort of mathematical teaching in public high schools that entirely conscientious and capable experts have brought out to view, the neutral says: "This is no concern of mine," or "Let the heathen rage," or "These crazy folk, having no real subject-matter to talk about publicly, must trump up talk about some bugaboo that will give them a hearing." The neutral attitude is very far from the attitude that the progressive teacher will take.

2. The belligerent attitude.

The spokesmen of this attitude counsel: "Blow up the enemy." "Get in the trenches of tradition and convention and 'stay put.'" Or in the *patois* of partizan politics their counsel is "stand pat." They attack the character of the enemy by suspecting that he had early trouble with his school mathematics and can't forget it, or that he now has a son or daughter who cannot learn mathematics. But this "mailed fist" type of argument gets nowhere, convinces nobody, and harms only its user. The progressive mathematical teacher will shun it as

he would the plague, for it is stultifying to every participant.

3. The clerical attitude.

This is the attitude of reverence for the past. What educators and thinkers for over two thousand years have regarded as fundamental and essential educational material must not now be called in question. It is a sort of educational sacrilege to pit one's individual judgment against the consensus of the ages. The past fruits of present curricular forms in the lives of great men or successful men, who testify to its benefits, ought to quiet attacks upon their present worth. This attitude is a flat denial of progress, fixes the stationary upon us, and cannot be assumed by the progressive mathematical teacher of today. It is the ancient Egyptian view and is unprogressive. We dare not forget—

"New occasions teach new duties, time makes ancient good uncouth."

In this day, when men's views are undergoing profound changes, when long cherished ideals are being replaced by new ones almost over night, we cannot hope for appreciable help from the clerical attitude.

4. The psychological attitude.

In the last twenty-five years a new attitude toward educational questions has been gradually working its way into the minds of men. Many middle-aged and older teachers of the conventional school subjects, teachers whose standards of educational worth were worked out to their own satisfaction before the new attitude had matured, have no adequate appreciation of the worth of psychological norms and standards, even though they may have found time now and then in their busy pursuits to do a little desultory reading in psychology. Indeed, it is the failure to recognize the psychological attitude toward educational questions that furnishes representatives for the three attitudes enumerated above.

The reason for the discomfiture, where it exists, among mathematical specialists, particularly among professors of mathematics in colleges and universities, at the recent propaganda against school mathematics as organized and administered in current curricula, is that these persons have no psychological point of view at all. It is not a wrong point of view that causes the discomfiture, it is the complete lack of a psychological point of view. This is also the cause of the repeated appearance of the same old objectionable form of textbook for high school mathematics. The author has no psychological attitude at all

toward the problem of mathematical teaching, which is pre-eminently a psychological problem. The attitude of the author is either *empirical*—mere habituated classroom procedure—or it is purely *mathematical*. The author tries to produce a good text. He has no malice toward a good text. He simply doesn't know what a good teaching text is, separate and apart from the grooves of his habituated practice. His weakness is not glaringly revealed yet, for the choosers of texts are as lacking in psychological attitude as he is. Moreover, the users of the text thus chosen have been merely habituated to the same type as has the author himself. The whole cause of the attitude of pugnacity toward the school critics of mathematics grows out of lack of any psychological attitude, while at the same time the tenacity of the present unsatisfactory *status* of high school mathematics is due to the same lack in school people who occupy critical places between the author and the child. The progressive teacher will not unduly quarrel with this *status* of things. He will simply recognize it as a fact, will see to it that he himself has a psychological attitude, will seek encouragement in the thought that as the more recently qualified recruits to the ranks of teaching become more numerous and influential, this condition will be corrected, and he will regard these extra-mural attacks as corrective agencies. The progressive attitude must be the psychological attitude.

The psychological attitude implies an ability and a willingness to see a fault, even when it is one's own. It demands open-mindedness to arguments both for and against. It does not regard change, even great change, as sacrilege, but rather as a professional need, if not necessity. It meets argument with argument. It neither coaxes nor cajoles; neither grouches nor grumbles; resorts to neither poisoned gases nor organized resistance. It believes in the ultimate perseverance of the saintly. It is always pacifically perseverant along established lines of principle. The psychological attitude is the progressive attitude today.

THE VIEWS OF THE PROFESSIONAL TEACHER.

II. Right attitude starts one right, but right views are what hold him right. The progressive teacher must not only face and start right, he must keep right. Here again there are four aspects of educational view that the progressive teacher will not neglect.

1. The educational view.

Of the vast body of mathematical material from which we might select what we will use for educational purposes, some parts are more appropriate than others. The educational view is that the mathematical material needed for the curriculum must be of the sort that faces both inward and outward. For example, the triangle is important because of its general relatedness to all sorts of plane rectilinear figures. The properties of nearly all plane figures may be derived by analyzing the figure into some form of triangle, after the properties of the triangle itself have been made out. This is the inward face of the theory of the triangle and from it comes the scientific value of the triangle. But many problems of construction, of surveying, etc., that arise in everyday life are solved by the aid of the theory of the triangle as a tool for general non-mathematical use. This is the outward face and from it the triangle gets a utilitarian value. Those parts of the general body of mathematical material that have both faces, the outward and the inward, are what should furnish curricula with their material. This principle will be an *accepted* and *working* view of the progressive mathematical teacher.

2. The mathematical view.

The mathematical view is that mathematical principles face only inward. Perhaps no high school teacher holds this as a conscious view for the control of teaching, but the difficulty is that he teaches, quite unconsciously, as though this were his view. He uses vocational or physical situations to exemplify, or to illustrate, mathematical principles, and uses them only in this way. He rarely, if ever, uses mathematical technique purely as a tool to resolve some scientific, or social or industrial situation. The text rarely, if ever, furnishes such situations for mathematical exploitation, and it is doubtful whether it should. But the teaching should not omit, nor even minify, this instrumental use of mathematics, for most young persons get whatever confidence they have in the worth of mathematical study from the feeling that such study confers power over the quantitative world. They develop an interest in the inward aspect of mathematical relatedness, some slowly, some rapidly, but all gradually as the mathematizing proceeds to later stages. Faith and interest in mathematical effort of both sorts, both that which aims at mathematical insight and grasp and that which exhibits power of use, must be the continual aim of the progressive teacher. He needs to be particularly careful not to read his own

mathematical interest into the early classes. He should with them be continually employing the utilitarian possibilities on local and familiar problematic situations of an extra-mathematical character. Much more than the customary emphasis upon real applications in which well mastered mathematical principles function as real tools is what I am claiming the progressive teacher should do today.

3. The social view.

A third view is that school mathematics should have high value as giving social, occupational, and vocational insights and power. We have not yet found practicable ways of doing this. But we must not yet give up the task. It means teaching the formula, the equation, the function, the graph, logarithms, etc., much earlier than we do. This is the social view, and is one of the dominant notes of secondary education today. The progressive teacher will find some way of getting himself into friendly relations to it in practice. He will at least not ignore it, nor oppose it.

4. The rational view.

A fourth view that the progressive mathematics teacher must employ explicitly is what we shall call the rational view. It is that the teacher should charge himself with the professional duty of training his pupils to take a rational attitude toward their school tasks, to the end that they may come to assume this attitude toward the tasks of life. We know that youth are anxious to do the mere technique of mathematical work, and that they shrink from, sometimes even resent, trying to give the reasons for the doing. By the persistent "whys" of mathematics we can and should break up this shallow satisfaction and establish the real student attitude of wanting to know why. Progressive teachers will train to the rational attitude in mathematical study. This is a widespread and a crying need in our public schools.

The progressive mathematics teacher will keep his mind clear on all four of the views, the educational view of mathematics, the mathematical view, the social view, and the rational view, and conform to all of them as his ability and experience show him profitable ways of doing so.

The Values of Mathematical Education.

Right attitude and right views prepare the professional teacher for a scrutiny of the *values* of mathematical education. Critics of our work have claimed that there is no general agree-

ment amongst us as to the aims and values of our work, and that whatever they are, our work is not realizing them with large numbers of our pupils. This, they say, is a strong reason why our subjects should be made elective. It is not my purpose here to enter a rejoinder. I do say that we may regard the following values of good school work in mathematics as almost, if not quite, universally accepted, and that it is the duty of the professional teacher to accept them and to undertake explicitly to secure an appreciable measure of all of them with all his pupils.

1. The formal value.

This means the value represented by a facile measure of skill in the direct use and manipulation of mathematical symbolism. Mechanical though it be, one will hardly make any sort of use, instrumental or scientific, of mathematics, if a considerable part of his mental energy is used up in the mechanics of mere symbol manipulation, and only the *residuum* is available for energizing against the problem. Without sufficient skill in mathematical mechanics for easy manipulation, mathematical symbolism actually encumbers thought, and is a nuisance. Enough skill to keep mechanics out of the way of thought is the ideal, and the progressive teacher will not fail to strive at least for this degree of formal skill.

2. The literary value.

This means the value represented by the ability to interpret popular scientific articles and books. This ability is needed by every high school pupil, and the progressive teacher of mathematics will secure it.

3. The instrumental value.

This is only a higher measure, which can be attained by many high school pupils, of the literary value. It means the ability to read and interpret intelligently scientific and professional subject-matter of the precise quantitative sort. It is to include also the ability to use the technique of mathematics in dealing with scientific and engineering facts and principles. The progressive teacher will give considerable attention to attempts to realize this value, especially in the later courses.

4. The scientific value.

This value is intended to include what may be called the vocational or mathematical value. It is such a degree and kind of mastery of elementary mathematical *technique* and *rationale* as the prospective specialist in mathematics must have. This

value perhaps need not be insisted on here, for it is the sort of value we are now almost universally attempting to secure for all. I mention it here because it must not be neglected by the progressive teacher, even though other values are just now crying loudly for more attention than we are giving them.

5. The transfer value.

Mathematicians and mathematical teachers are in sufficiently full agreement as to whether this phase of value exists, and the professors of education, formerly considerably at loggerheads about it, are coming to an agreement that something carries over. Precisely what it is that carries over, and to what extent it carries over, remain yet to be answered. That some sort of gain in attitude toward problem thinking and some measure of the technique of problem solving goes over into fields in which problem thinking is characteristic is conceded by nearly everyone. If we should make our teaching such as to call for a great deal more problem thinking from the pupil, we shall surely be increasing this value of mathematics. Learning model demonstrations is not problem thinking, nor is symbol juggling. Problem thinking is analyzing, organizing and controling problematic situations—situations which produce the dilemma attitude in the learner's mind—and we do too little with this sort of thing in our classes. There is too much "fixing things up" so that the pupil may never be troubled by a dilemma, too much teaching him everything he needs before he needs it, to admit of much training in problem thinking in our present day teaching. The progressive teacher will produce some dilemmas for the pupil himself to dispel. More important mathematical things should be taught obliquely, as tools needed in problem solving.

Norms for Gauging Mathematical Values.

The progressive teacher will seek to aid in setting up standards for judging the special achievements of mathematical study. Such questions as: "Does an ever widening deviation of abilities in your class indicate good, bad, or indifferent teaching?" can be answered by the high school teacher in the pursuit of his regular work. I raise the question: "Why is an ever widening deviation in abilities in high school classes in mathematics so general today?" The progressive teacher will associate himself as occasion offers, as our chairman has been long doing, with some professor of education and help to set up suitable

study tests, ability tests, and attainment tests. While the psychological and the mathematical attitudes are so divergent as they now are, this is a practicable way of getting both attitudes in function. Perhaps a standard grading system might be worked out thus. We always have a higher regard for the ideas of a man with whom we have worked than we have from just hearing him recite our weaknesses. Let us get together. Instead of chafing under the findings of the school surveyors, it will be much more progressive for us to help set up more adequate standards, and then after weaknesses have revealed themselves let us be broad-minded enough to bestir ourselves to remove them.

A Closing Reminder.

Just one more reminder in closing. Nearly every educational writer and general educational authority who has recently tried to give us suggestions for constructive improvement has urged that we introduce the formula, the graph, and logarithms in the first year high school course in mathematics. None of us is even attempting to do this, nor has any good reason for not trying this as yet appeared. Why is this? Do actual teachers regard these suggestions for modernizing high school algebra as of no value? Has anyone tried out these suggestions? The recent texts are doing a little half, or quarter-hearted work with the graph. But the formula and logarithms are not seriously tried by anyone. Why is this? I close with the question, without even asking why not introduce the function idea earlier in algebra.

MEETING OF THE TEACHERS OF SECONDARY SCIENCE OF DISTRICT I, VIRGINIA.

This meeting was held with the Science Club of the State Normal School for Women, on Friday, March 15, during the Educational Conference which met at the Normal, the 14th, 15th, and 16th. A round table discussion, conducted by Miss Flora Bryson, Head of the Science Department of Radford State Normal School, created considerable interest. The topic, "First- and Second-Year Science in the High School," was discussed from the standpoint of the tendency to substitute agriculture and domestic economy for physical geography and the biological sciences. An encouraging feature of the meeting was the presence of superintendents and college men who exchanged views unreservedly.

Miss Bryson read a paper before the patriotic session on Saturday, urging better science teaching in the high school in order to give "more of the ninety-five per cent a chance," and thus increase the number of men and women from whom the nation is to draw her scientists for research.

Flora Bryson.

MAKING WALL MAPS OF LIMITED AREAS.

ROBERT M. BROWN,
Normal School, Providence, R. I.

In teaching geography of the home locality, it is frequently necessary to have maps of areas of which map publishing houses cannot supply the needs because of the limited demands. Most town, county or state maps which are available are not issued primarily for teaching purposes and the copies which are used are ordinarily constructed for close study not suited to class-room uses. Teachers must be depended upon to supply this lack and prospective teachers need some training in preparing for their classrooms or in translating to the blackboard the maps and charts necessary to the best presentation of the lesson. In a state as small as Rhode Island, it is possible to mount the topographic sheets of the United States Geological Survey covering the whole state on a single canvas and the resulting map is, from the point of view of size, convenient and satisfactory. As a wall map for class use, however, it falls far short of perfection. The outline of the state and the counties stand out in fair prominence but no other feature can be read with any degree of comfort or accuracy. The contour lines, which on some combinations of the topographic sheets are discernible across a room, on the Rhode Island map, because of the low relief, sink into insignificance. A few maps of Rhode Island are published, but there is no map which is fitted to be exhibited on the walls of a schoolroom for a class exercise in Rhode Island geography. This condition, with varying degrees of emphasis, is true of most parts of the United States.

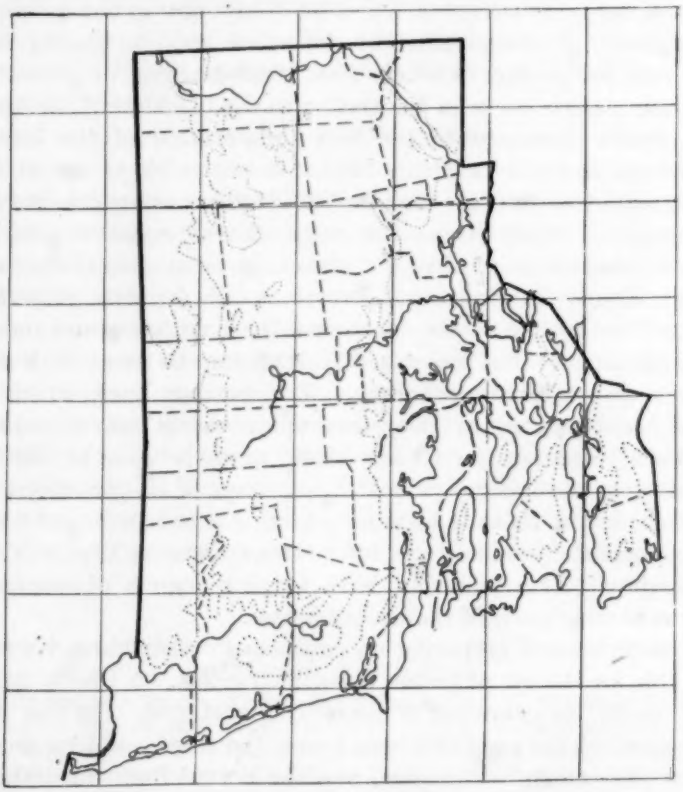
The process of preparing on cardboard or blackboard a map suitable for the use of a class is outlined below. A Rhode Island map ready for enlarging is inserted as a sample. On this map the short dashes are town boundaries, the short and long dashes mark the county boundaries, and the dotted lines the 100 and 500 foot contour lines.

ENLARGING.

A. Select a map for enlargement which contains the features desired. If no such map exists, it may be necessary to reproduce one, as has been done in the case of the Rhode Island map with which this paper is illustrated. The outline with town and county boundaries may be taken from an atlas, and upon this as a base the contour lines may be inserted from the topographic sheets

of the Geological Survey or from any other authoritative source. The contour lines of the Rhode Island map are taken from the International Map of the World (1:1,000,000 Sheet K-19 U. S. G. S.), and the Topographic Sheets for Rhode Island.

On the map to be enlarged draw squares completely covering the section desired, as in the figure. The size of the squares must be determined by the detail of the map. In general, one centimeter or one-half inch squares may be the rule.



B. Select a sheet of heavy white paper for the map. The commercial size (28½ by 22½ inches) makes a map of suitable clearness if the map is devoted to a single feature. On this paper make the same number of squares as on the smaller map (eight by seven in the Rhode Island illustration), each square in this case being as many times larger than those of the original map as the size of the paper permits. Three inch squares on the Rhode Island map to be constructed would take 21 inches in width and 24 in length, leaving an ample margin.

Do not make the lines of the squares on the cardboard prominent; the lightest line possible will avoid the necessity of erasing and the sizing of the paper will not be marred. The squares should be made carefully: squares mixed with rectangles will distort the map.

C. When this has been prepared, draw on the enlarged network, square by square, the map as it appears on the smaller network. This may be done free hand without any loss in effectiveness or accuracy. Locate by the same process such political boundaries as are desired, rivers, lakes, cities, islands and any other feature.

OUTLINING.

D. Draw the boundary line of the area following the pencil mark which indicates it, with a red crayon (madder lake) for land boundaries and blue (ult. blue) for river and coast lines. The difference between the political boundaries of the state and the political boundaries of town or county may be indicated by the width of the line or by continuous and dotted lines. Draw a margin (black) around the area mapped so as to center the figure and finally cut the cardboard so that the edges may be properly located with reference to the marginal lines. This will give an outline map of classroom size on which may be charted such geographic features as form the subject of the lessons.

CHARTING.

E. Maps displaying climatic data, natural resources, transportation lines, location of industries and density of population are valuable in teaching. A uniformity of condition in any one of these lines which exists over the whole area need not be charted. Thus, if the annual rainfall does not vary in any appreciable amount within the limits of the mapped area, a rainfall map will not be worth while. The Census Bureau of the United States has issued state maps showing densities of population by counties but in many cases, as in Rhode Island, no lesson can be drawn from them, while a density of population map by towns displays definite and clear responses to topography and transportation routes. Conventional signs for all of these features are given in most geography textbooks. The contour lines may be omitted from these maps as confusing detail.

TOPOGRAPHY.

F. The topographic wall map of any small area which is taught as a unit in the geography class is an invaluable aid.

It is sometimes argued that the construction of these maps by the teacher adds another task to her already busy day. The time wasted in teaching lessons on the topography of Rhode Island, for instance, without a proper map is much more than sufficient to construct all the Rhode Island maps necessary for use in the grade schools.

In making a topographic map, the contour lines are necessary. Proceed with the coloring for topography. Use green (medium green) for heights up to 500 feet. In areas of low relief, as in Rhode Island, two shades of green may be used and the 100 or 200 foot contour line, as is convenient, may separate them. For heights between 500 and 1,000 feet use brown (a light application of burnt sienna); between 1,000 and 2,000 feet, brown (a heavy application of burnt sienna); between 2,000 and 5,000 feet, dark brown (a light application of burnt umber); between 5,000 and 10,000 feet, dark brown (a heavy application of burnt umber); and above 10,000 feet, magenta. For water bodies use blue (ult. blue).

Begin all shades with light strokes. It is easier to darken the shade than to reduce it. Apply all colors with a horizontal stroke. This will give a uniformity to the effect and avoid scratchiness. Do not cross boundary lines in coloring and do not run into boundary lines, as the colors will mix.

LEGEND.

G. The legend of the map may now be added. A small rectangle within the marginal boundary lines may be used for this purpose. A scale should be inserted under the caption. This may be taken from the original map by enlarging it according to the square method to the corresponding size of the wall map. The explanation of the colors or of the information charted may be made according to the methods employed by any good map as the topographic sheets of the United States Geological Survey. Direction symbols, either an arrow or parallels and meridians, should be added.

In making wall maps, it will be found upon trial that the best results in the grades are gained from maps which display a single feature. No general rule, however, can be made as the states differ in kind and amount of detail. In Rhode Island it is possible to place upon the topographic map the town boundaries, the city centers and the railroads without causing confusion. Another map is needed to show density of population. The productions of the state cannot, because of their variety and range, be easily charted on a single sheet.

THE OIL IN CHERRY PITS.

By HAROLD L. MAXWELL,
Cornell College, Mount Vernon, Iowa.

It has been the subject of much speculation as to how the Germans have been supplied with fats for food and to furnish the glycerine from which the important explosives, dynamite and nitro-glycerine, are made. They have been charged with having extracted fat from their enemy dead to be used in making the explosives.

An important source of oil in Germany is doubtless the cherry pits, and it is quite likely that German thrift and efficiency would not be slow to utilize that material. There is scarcely any other country on the globe where the cherries have reached so high a degree of perfection as in Germany. Cherry trees are everywhere and the cherries are unusually large and constitute an important article of food during the early summer. We thought it might not be devoid of interest to investigate the oil content of the cherry pits.

We secured a quantity of the dried seeds of the common cherry, "Prunis Erratus," and by cracking we obtained fifty grams of the kernels. These we crushed in a mortar, removed to a cloth sack and placed in the flask of the ether extraction apparatus. The oil which adhered to the mortar as a result of the crushing was washed with ether and added to the contents of the flask.

After the extraction had continued for fifty-six hours, the oil laden ether was taken from the extraction flask and great care was exercised in order to insure against the loss of even the smallest quantity of the oils. The ether and oil mixture was distilled at the lowest possible temperature. The boiling point of the ether being 34.9° the mixture began to distill at a slightly higher temperature, about 36° C. By fractional distillation the oil was separated from the solvent. To insure the evaporation of all the ether, the oil was placed in an open beaker and heated on a water bath at 76° C. for three hours. After this treatment even the faintest trace of ether could not be detected.

The yield was unusually large. From the fifty grams we secured 18.8 grams of the oils or a yield of 37.6 per cent. The oils have the characteristic odor of almonds. The taste is pleasant, resembling nuts. They are light amber in color and have about the consistency of warm castor oil.

The German Pharmacopeia states that pure almond oil should remain clear at -10° C. This specimen became opaque, showing that we had a mixture of oils and not one individual. At low temperatures the oils showed marked changes. The first change in color began at -5° C, when white globules separated out and settled to the bottom. This indicated that one of the oils solidified at that temperature. We kept that temperature constant until all the oil which had a tendency to solidify had separated out. We set this oil aside for further study, which we record later. The amber oil, which constituted about 90 per cent of the whole oil content, was drawn off with a pipette and subjected to lower temperatures. At -18° C there was no sign of solidification but at -19° C the oil became viscous, while at -20° C it began to become solid.

The specific gravity of the oil was next determined by weighing out several portions of two cubic centimeters each on a watch glass of constant weight, and computing the weight per centimeter of the oil. We found the sp. gr. to be .922, .925 and .924 in three respective cases. This is consistent with the results secured by T. Maben, who investigated the oil in almond nuts. He records the sp. gr. of that oil as .918 to .923.

Two grams of the oils were weighed out on a constant watch glass and set aside at room temperature for a period of forty hours. After that time the oil was weighed again, noting the loss in weight. The oil is slightly volatile, since during that period it had lost $1\frac{1}{2}$ per cent of its original weight.

In determining the saponification equivalent of the oil under examination, we first prepared a normal solution of KOH in absolute alcohol. This was done by dissolving 56 grams of KOH in 800 cc. of the solvent and then diluting to a litre. We weighed 4.317 grams of the oil into an eight ounce flask and added to it exactly 30 cc. of the alcoholic solution of KOH. The flask was connected with an inverted condenser and the contents kept at a boiling temperature for thirteen hours. We cooled the flask and added 200 cc. of water. Then to determine the amount of the oil which had been saponified by the KOH, we titrated the contents of the flask with normal HCl, using phenolphthalein as an indicator. The difference between the number of cubic centimeters of the normal KOH used and the number of centimeters of normal HCl necessary to neutralize the remainder after the saponification represents the number of cubic centimeters of the KOH neutralized by the oil. Then,

knowing the strength of the solution and the nature of the oil, we can determine the percentage of the saponifiable oil. The saponification equivalent is the object of this experiment, and to compute that we divide the weight of the oil in milligrams by the number of centimeters of KOH solution neutralized by the oil. In this case we found it to be 276.8. E. Valenta investigated the oil from almond nuts and found the saponification equivalent to be 285, and that in some cases it ranged as high as 296, depending on the purity of the specimen. Thoerner, in a study of the mixed fatty acids of almond oil, found the equivalent as low as 204.

Taking first the light amber oil, which constituted the main portion of the mixture of oils, we added two drops of concentrated sulphuric acid to twenty drops of the oil. At first there was no color, but on stirring with a glass rod the oil and acid mixture became brown and in a few minutes it began to solidify. This also is characteristic of almond oil.

Some of the smaller portion of the oil which had separated out on being cooled in the first part of the investigation was given the same treatment with a few drops of sulphuric acid. When the mixture was stirred, the color turned from a yellow to a reddish brown with a purple cast. This indicated the presence of Arachis oil, the principal oil in peanuts. There was only a small amount of this oil present in the specimen. This was not sufficient for a complete and thorough analysis.

There are three sources from which almond oil may be obtained: Almond nuts, peach kernels and apricot kernels. Then since the cherry seed belongs to no one of these three classes, our next question might well be: Which one of the three does it most resemble?

Samples of almond oil from each of the three sources vary in specific gravity, bromine absorption, and color tests. In the first two instances the variation is so slight that, allowing for even the smallest error, the line of difference is indistinct. It is then the color tests that mark the dividing line between the almond, peach, and apricot oils. The zinc chloride test is the one employed as follows: Add five drops of the strong zinc chloride solution to ten drops of the oil. If there is no change in color after stirring, the oil is identical with that from the almond nut. If the color changes to purple or brownish purple, the oil is from the peach kernel. While if the mixture changes to a muddy or a dirty brown, the oil is the same as that from the apricot kernel. In the sample of oil being examined there

was no change of color, showing that the oil in this analysis is the same as from the almond nuts.

The taste and odor of cyanogen in the freshly cracked cherry pits is evidence of the presence of nitrogen. By the use of the Gunning method we determined the percentage of nitrogen in the kernels and found no less than 5.6 per cent. It is to be expected that the ether extraction would remove a part of the cyanogen with the oil. We took a gram of the dried residue after all the oil had been extracted and made another nitrogen determination. In this we found 4.2 per cent of nitrogen, showing that the main portion of the nitrogen was neither extracted by the ether nor expelled by the long heating on the water bath.

The residue from the crushed cherry pits was taken from the flask and dried in the air for ten hours. Then it was heated on the water bath at 100° C for fifteen hours to expel the remaining ether and the moisture. The dry residue was weighed and the loss in weight found to be 20.9 grams. The oils extracted weighed 18.8 grams, leaving a difference of 2.1 grams. This is no doubt the weight of the water expelled from the residue when it was heated to drive off the remaining ether.

When cherry seeds or oil bearing nuts are ground up with cold water, the amygdalin breaks up in an emulsion. The oil is partly broken down in the process and glucose sugars constitute one of the resulting products. To confirm the presence of the glucose sugars in the water extraction, we treated a quantity of the dried seeds with water for twenty-four hours. We titrated a fractional part with standard Fehling solution and found 13.8 per cent of sugars present. Reaction:

$$C_{20}H_{27}NO_{11} \pm 2H_2O = C_7H_6O \pm HCN \pm 2C_6H_{12}O_6$$

The cherry oil, which has been found to be essentially the same as the almond oil, consists of olein with a small quantity of stearin and palmitin. Olein is the chief constituent of the fatty oils and may be made by heating glycerine with an excess of oleic acid at 204° C. Its formula is $C_{57}H_{104}O_6$.

It is not to be expected that the Central Powers, with their urgent need of oil for food and explosives, have overlooked such a productive source of glycerine as we have found in the cherry pits. The production of the countless tons of explosives necessary to carry on a war has called into service every resource of the nation. This is an item, then, not to be underestimated, for already the cherry seed oil has contributed its bit to the great world war.

PERSONAL JUDGMENTS AS A FACTOR IN GRADING.

By J. L. ZERBE,

University of Pittsburgh, Penn.

After the class had completed over a half year's work in psychology and had had some animated discussions on personal judgments in school grading, they were asked to rank according to merit, best first, next best second, etc., and to grade in percentage figures five specimens of a half-lap joint. The class was composed of nine adult students in a technical school, who had completed a year and a half of woodwork; some were grading wood projects in their substitution teaching in the public schools, and each had had the criticism and grading of his own half-lap specimen by the instructor of manual training. Some uniformity in grading such a specimen might be expected. The following tabulation gives the results of these personal judgments in ranking and grading of the five specimens:

	Ranking of Specimen					Percentage valuation of Specimen				
Student	1	2	3	4	5	1	2	3	4	5
A	1	3	3	5	1	80	65	65	50	80
B	2	4	5	3	1	78	75	72	77	80
C	2	3	4	5	1	90	85	80	75	95
D	2	4	5	3	1	84	78	75	80	85
E	2	2	2	2	1	65	65	65	65	75
F	1	3	4	5	2	90	75	70	65	80
G	2	4	5	3	1	81	73	70	76	85
H	2	5	4	3	1	80	60	69	73	90
I	1	2	5	4	2	90	80	60	70	80

It will be noted that only three students, B, D, and G, agree on the rank placement, while there is no agreement as to the percentage grading. One of the students grades four specimens the same, while other students rank these four from first to last place and give a percentage valuation from 50 to 90.

On four subsequent weeks these same students were asked to re-rank and re-grade these specimens. The students did not anticipate a future grading, nor were they allowed to refer to their former grades. In order to safeguard any carrying over from week to week, each specimen was given a new number each time, thus losing its former identity. The variation in the amount of percentage, the average grade given at each date, and the average variation which represents the deviation of the average percentage of any one time from the total average of the five dates for each specimen are given in the accompanying tabulation. At the bottom of each column is the deviation for each specimen for each time, the deviation of the variation, the total average grade and the total average variation.

The recapitulation indicates that without some standard one judgment is as good or as faulty as any other. Student A, whose average is 65, has a different standard for work accomplished than has student C, who places the valuation at 85. A variation of twenty points on an average scale of 100 is a big step, yet each student considered his judgment as more or less absolutely fair. Student A places the poorest specimen 45 points lower than his best specimen; while B separates his by only 15 points. The judgments of the individual vary as much from time to time as do the judgments of different individuals.

GRADING OF HALF-LAP JOINT.

Student A	Specimen							Ave.
Date	1	2	3	4	5	Var.	Ave.	Var.
March 10	80	65	65	50	80	30	68	3
March 17	60	70	50	75	85	35	68	3
March 24	65	40	50	75	80	40	65	0
April 7	60	50	70	80	85	35	62	3
April 14	50	65	75	80	85	35	71	6
Variation	30	30	25	30	5	10	65	15

Student B	Specimen							Ave.
Date	1	2	3	4	5	Var.	Ave.	Var.
March 10	78	75	72	77	80	8	76	2
March 17	70	75	77	80	82	12	77	1
March 24	80	73	78	75	85	12	78	2
April 7	85	72	79	75	82	10	79	1
April 14	72	83	75	80	85	13	79	1
Variation	13	11	7	5	5	5	78	7

Student C	Specimen							Ave.
Date	1	2	3	4	5	Var.	Ave.	Var.
March 10	90	85	80	75	95	20	85	0
March 17	80	90	75	85	95	15	85	0
March 24	90	85	80	75	95	20	85	0
April 7	85	80	75	90	95	20	85	0
April 14	75	90	80	85	95	20	85	0
Variation	15	5	5	15	0	5	85	0

Student D	Specimen							Ave.
Date	1	2	3	4	5	Var.	Ave.	Var.
March 10	84	78	75	80	85	12	80	5
March 17	60	55	65	85	90	35	71	4
March 24	85	60	70	60	90	30	73	2
April 7	88	65	75	70	65	23	73	2
April 14	85	85	75	65	90	15	80	5
Variation	28	30	10	15	25	23	75	18

Student E	Specimen							Ave.
Date	1	2	3	4	5	Var.	Ave.	Var.
March 10	65	65	65	65	75	10	67	6
March 17	70	70	75	80	85	15	76	3

March 24	80	75	80	75	85	10	79	6
April 7	70	60	75	65	85	35	71	2
April 14	60	80	65	60	85	35	70	3
Variation	20	20	15	20	5	25	73	20

Student F

Date	Specimen 1	2	3	4	5	Var.	Ave.	Ave. Var.
March 10	90	75	70	65	80	15	75	0
March 17	90	85	75	80	87	15	83	5
March 24	85	80	70	80	90	20	81	3
April 7	85	65	60	75	80	15	73	5
April 14	60	83	77	73	85	23	76	2
Variation	30	20	17	15	10	8	78	15

Student G

Date	Specimen 1	2	3	4	5	Var.	Ave.	Ave. Var.
March 10	81	73	70	76	85	15	75	1
March 17	69	76	79	85	88	19	79	3
March 24	84	65	71	60	90	30	74	2
April 7	85	70	79	75	85	15	78	2
April 14	71	80	65	60	85	25	72	4
Variation	16	15	14	25	5	15	76	12

Student H

Date	Specimen 1	2	3	4	5	Var.	Ave.	Ave. Var.
March 10	80	60	69	73	90	30	74	2
March 17	60	60	65	85	90	30	72	0
March 24	85	65	70	60	90	30	74	2
April 7	90	60	65	60	85	30	72	0
April 14	60	80	85	60	85	25	70	2
Variation	30	5	20	25	5	5	72	6

Student I

Date	Specimen 1	2	3	4	5	Var.	Ave.	Ave. Var.
March 10	90	80	60	70	80	30	76	3
March 17	60	65	70	80	90	30	76	3
March 24	90	75	85	80	95	20	85	6
April 7	85	65	80	79	90	25	78	1
April 14	70	90	80	65	95	30	80	1
Variation	30	25	25	15	15	10	79	14

Recapitulation

Students' Average		Total Var.	Grades Lowest	Highest
A	65	12	40	85
H	72	6	60	90
E	73	20	60	85
D	75	18	60	90
G	76	12	60	90
F	78	15	60	90
B	78	5	70	85
I	79	14	60	95
C	85	0	75	95

Another study: The accompanying sheet of five specimens of handwriting was placed before 361 advanced students in a normal school and they were asked to grade each according to a percentage figure and in terms of excellence, good, fair, passed and failure as indicated at the bottom of the sheet. Graph 1 to 5, plate 2, shows the distribution of ratings in terms of excellence, good, etc. It is to be noted that each specimen receives a vote for each classification, even the best specimen is graded failure or non-passed by six and the poorest specimen is ranked excellent by fourteen students. Nineteen normal school and seventeen high school instructors were asked to grade these in a similar manner. The ranking value of each specimen was determined by weighing[1] and the order of merit for each group is:

Specimen No.	361 Normal School Students Ranked	19 Normal School Instructors Ranked	17 High School Instructors Ranked
1	3rd	3rd	3rd
2	4th	4th	5th
3	1st	2nd	2nd
4	2nd	1st	1st
5	5th	5th	4th

To repeat: only one specimen is ranked the same by the three groups. Comparing the judgments of the individuals with the ranking by the total group to which they belonged, the percentage of agreement is:

Number of Agreements	361 Normal School Students	19 Normal School Instructors	17 High School Instructors
0	23%	5%	59%
1	36	37	41
2	18	26	0
3	17	32	0
4	5	0	0
5	1	0	0

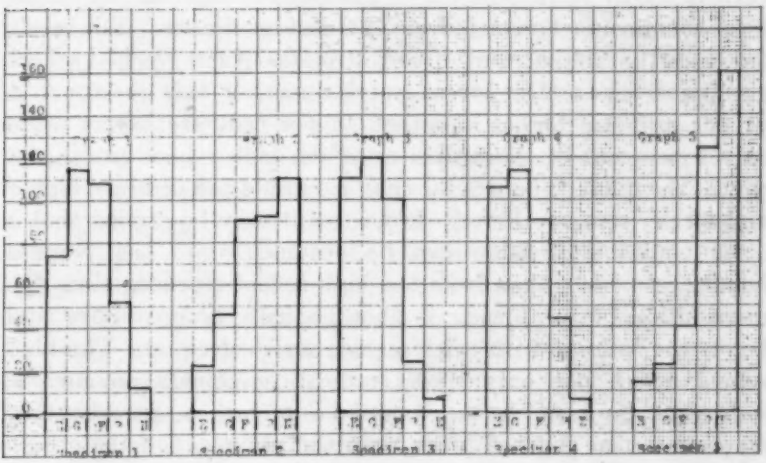
In other words, 23 per cent of the 361 adult students, 5 per cent of the normal school faculty and 59 per cent of the secondary school teachers failed to rank any one specimen in the order of merit established by the total judgments of the group to which they belonged. A large percentage of judgments failed to agree with any order of merit.

The distribution of percentage grades for the entire number of judges ranges from 10 to 100. If the judges were consistent and graded these specimens with as much care with the terms as with the per cent valuation, it is fair to suppose that the numerical valuation for any specimen represents the percentage notion for the term used. That is, if one grades specimen 1

85 per cent and then gives it a term grade of fair, we may say that in this teacher's mind 85 per cent represents fair. Thus we arrive at a numerical valuation for each term used and for each group and can then determine the number of points an estimate will differ from the average of the group. The range of per cents given by the high school teachers is: Excellent, from 90 to 95; good, from 74 to 94; fair, from 70 to 83; passed, from 40 to 80; and failure, from 25 to 70. The average values in per cents for the terms used for each group are:

	Excellent	Good	Fair	Passed	Failure
361 Normal Students	93%	89%	84%	78%	61%
19 Normal Teachers	92%	84%	82%	72%	60%
17 High School Teachers	93%	84%	77%	66%	50%

[1] *Vide* Thorndike, E. L., "Mental and Social Measurements," p. 211.



Grade in Per Cent	Grade in Terms
1	Excellent
2	Good
3	Fair
4	Passed
5	Failure

Again the lack of uniformity is to be noted and also the value of some standard, no matter how weak the standard may be, in bringing about uniformity. The two normal groups approximate each other's values for the reason that some vague standard existed between the instructors and the students. All knew that 60 per cent meant a failure grade and that fair work was usually rated 80 or 85 per cent. Many instructors exempted from finals on a grade of 90 per cent or above and exemption meant more or less a perfect grade. The distribution

of the average values by the Normal students differs from that of the Normal instructor by 14 points, from that of the high school teachers by 35 points, while the Normal school teachers' average differs from that of the high school teachers by 32 points. The deviation from the percentage valuation by the two groups of teachers is:

	Normal School Teachers						High School Teachers.					
Specimen	1	2	3	4	5	Total	1	2	3	4	5	Total
Value	82%	72%	84%	92%	60%	78%	77%	50%	84%	93%	66%	75%
No. equal	0	1	1	1	10	13	1	4	0	0	0	5
No. higher	6	12	8	5	8	39	5	7	8	1	8	29
No. lower	13	6	10	13	1	43	11	6	9	16	9	51

In order to compare the two groups, the distribution in the total column was converted into percentage figures. The result indicates that 14 per cent of the estimates of the Normal school group just equals the average percentage for that group; that 41 per cent are higher and that 45 per cent are lower; while only 5 per cent of the estimates of the high school group just equals the average figures for that group; 34 per cent are higher and 60 per cent are lower. From this it may be argued that a more equitable decision can be obtained from the Normal faculty as a body than from the high school teachers, since the distribution of the former is about equally placed above and below the average with a fair percentage just equal. The high school group not only shows radical judgments among the individual teachers but the standard is of such a character that 60 per cent are marked lower than the judgment of the group. The fact so often expressed is here shown, i. e., that with any body of teachers the same problem will be variously interpreted and the assumed basis for judgment by the individual teacher is not the assumed basis for the entire group. A further point may be deduced that where the administrative authorities make known from time to time the general distribution of grades, consciously or unconsciously the grading of the individuals approximates more closely the general distribution of the group. The Normal policy was to unify without objective standards the work of the school so that the "Dreaded State Board of Examiners," who examined and graded wholly on a personal judgment basis, might not find great discrepancy in the work of the various teachers. The high school group was composed of students in an advanced pedagogical course who

taught in nine or more high schools in as many different communities.

Three months after these specimens were first graded, 132 Normal students were again asked to grade them. The results of this grading show that they are less liberal in the range of distribution and that the percentage valuation has dropped to lower values. The agreement with the former judgments is:

Number of Specimen	1	2	3	4	5
Percentage of Agreement	17%	16%	23%	19%	33%

That is, seventeen per cent agree with their former estimate of specimen 1, etc. Thus the fifth specimen, which has been considered the poorest by so many, receives the largest percentage of agreement and yet that agreement is only 33 per cent. Again time has affected the personal judgment. If only one-third of these mature students agree on a specimen obviously so poor, what can be expected of the average teacher who has no standard other than the desire to have his or her teaching appear satisfactory to the administrative authorities?

One more study: The need of some definite system of grading or at least the advisability of some uniformity was made clear in a report sent by the Dean of Applied Industries, Carnegie Institute of Technology, to the members of his faculty. The facts presented were illuminated with graphs and tabulations and the plan of grading adopted by the George Washington University was given some prominence so that some tangible standard would be known to the entire faculty. It was thought that a mere presentation of facts showing the great need for uniformity would be sufficient to convince each member that his personal judgment was of little value and that in order to have uniformity for the distribution of honors he ought to conform to the average of the group or to some supposed standard which the group would adopt. The truth or falsity of this assumption is indicated in the accompanying tabulation.

Before presenting the tabulation, it might be well to indicate roughly the subject matter of the report. Twenty per cent of the 28,257 grades assigned during three years were below passing. Less than 5 per cent were honor rank or the highest grade, while 12 per cent of all grades given to graduates were of the honor rank. An average of 29 per cent of all grades given the night students were below passing, while only 20 per cent of that grade were given to day students. Of all grades assigned by the academic instructors, 51 per cent were below passing,

while only 25 per cent of grades assigned by the instructors of shop subjects were below passing. The teachers of academic subjects placed 19 per cent of all of their grades above the average or middle "C" grade, while the shop instructors placed 25 per cent of their grades above that point. The discrepancy in the grading of these two classes of instructors suggested that perhaps the school had accepted the motor minded rather than the mentally alert student. In order to satisfy this suggestion, a series of psychological tests was given to determine whether these students were less able to do academic work. The results of these tests given to 183 students representative of the student body indicated that the curve representing their mentality approximated very closely the probability curve for general distribution and that the skewed curve to the lower level of the academic instructor and that to the higher level of the shop instructors were not just curves for the students represented. The study further indicated that a little more than 40 per cent of all grades given by the twenty mathematical instructors were below passing. In English, 34 per cent assigned by the eight instructors were of the same value. Of all grades assigned, the "H" or highest grade was used 40 per cent in printing, 38 per cent in industrial history, 20 per cent in manual training, 18 per cent in telephony, 11 per cent in mechanical drawing, 8 per cent in electric wiring, 7 per cent in bricklaying, and 5 per cent in strength of materials; while in forging, estimates and cost, modeling, pattern-making, principles of design, sheet metal, and stationary engineering not a single per cent of all grades assigned attained the rank of "H." For three years, covering six opportunities of grading, one instructor did not give an "H" grade, another within that same time gave less than one per cent of that grade; while another, with practically the same students, placed over 70 per cent of his grades within the "H" rank and another gave 51 per cent of his the "H" distinction.

From the wide variation in the individual distribution, it seems evident that a greater uniformity was imperative if school honors and class distinctions were to be granted wholly on the scholastic standing as indicated by the personal judgments of the instructors. In fairness to all it might be stated that this report received no comment other than the letter of transmission which I sent to the Dean and which he included in the report. The following tabulation presents the deviation of grades from the suggested standard of the George Washington

University. The curve of distribution suggested by the George Washington University is that approximately 4 per cent of all grades granted by the instructor be rated as excellent or honor, 24 per cent good, 44 per cent fair, 24 per cent passed and 4 per cent failure.

The effect of this report is seen by comparing the amount of deviation for the first semester before the report was made known and that for the second semester after it was published. Column 1 indicates the instructor by letter, column 2 the type of student, day or night, column 3 the total letter of grades assigned by each instructor for each semester, the next five columns the amount of deviation for each class of grade for each semester, and the last column the total deviation regardless of signs.

DEVIATION FROM A CURVE OF DISTRIBUTION.

Instructors	Day or Night	Total No. Grades		Amount of Deviation. Honor		Merit		Credit		Passed		Failure		Total	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
A	D	133	156	+ 4	+ 4	− 7	− 5	− 1	+ 3	− 1	− 6	+ 5	+ 4	18	22
B	D	11	38	− 4	− 1	−15	+ 4	+11	− 7	− 6	+ 7	+14	− 4	50	23
C	N	55	90	+ 1	+ 6	−12	− 6	− 9	− 1	+12	− 6	+ 8	+ 7	42	26
D	D	60	80	− 4	− 2	− 9	− 3	− 6	+14	+13	− 4	+ 6	− 5	38	28
E	N	35	37	+ 7	+ 7	+10	− 3	−21	− 8	+ 5	− 3	− 1	+ 7	44	28
F	D	84	86	− 2	+ 2	− 1	− 4	+ 1	+12	− 5	− 9	+ 7	− 1	16	28
G	D	46	55	+14	+ 9	+ 3	− 6	−20	− 8	−11	− 2	+14	+ 7	62	32
H	D	70	118	+16	+ 9	− 1	− 5	−21	− 5	− 3	− 6	+ 9	+ 7	50	32
I	D	41	62	+14	+14	− 3	− 3	− 4	− 4	− 3	− 9	− 4	+ 2	28	32
J	D	183	139	0	+ 3	−16	+13	−10	+ 1	−40	+ 4	+46	−13	112	34
K	D	103	124	+ 6	+ 9	− 8	−10	+ 8	0	− 5	− 7	− 1	+ 8	28	34
L	D	107	129	− 4	− 3	+ 3	+ 9	+ 4	+ 6	0	−14	− 3	+ 2	14	34
M	D	47	73	− 1	− 2	− 5	−13	−19	− 4	− 4	+12	+29	+ 7	58	38
N	D	49	30	− 4	− 4	− 8	−11	−32	−19	−16	0	− 4	− 4	64	38
O	D	102	116	− 3	− 1	− 4	−11	− 8	− 1	− 3	− 8	− 2	−19	20	40
P	D	34	23	− 1	0	− 4	− 2	− 4	− 9	−15	−11	−16	−18	40	40
Q	D	181	176	− 1	+ 3	− 1	+14	+21	+ 4	−17	−17	− 2	− 4	42	42
R	N	126	111	− 1	+13	− 1	− 2	− 5	+ 8	− 1	−16	− 1	− 4	9	43
S	D	65	43	− 4	− 4	−16	− 3	+44	+18	−20	−15	− 4	+ 4	88	44
T	D	71	62	− 4	− 1	−12	−16	+ 1	+12	+ 2	+10	+13	− 5	32	44
U	D	60	56	− 4	0	+ 3	− 4	+ 2	+23	− 2	−16	+ 1	− 3	12	46
V	N	48	34	− 4	− 7	+17	+12	+ 8	+12	−17	−13	− 4	− 4	50	48
W	D	112	100	− 1	+ 2	−10	−10	+ 3	−14	− 1	+ 4	+ 9	+18	24	48
X	N	66	51	+16	+10	− 5	− 6	+ 1	+14	−17	−17	+ 5	− 1	44	48
Y	D	131	138	− 4	− 3	−12	−13	+ 9	+21	− 6	− 8	+13	+ 3	44	48
Z	N	18	15	− 4	+ 9	− 2	+13	−16	− 1	+ 4	−24	+18	+ 3	44	50
Aa	D	36	57	+16	+12	+23	+16	−11	− 7	−24	−15	− 4	− 2	78	52
Bb	D	105	104	+ 8	− 2	+20	− 8	0	+26	−24	−13	− 4	− 3	56	52
Cc	N	23	17	+18	+ 4	+15	−23	−35	+16	+ 2	+ 7	0	− 4	70	54
Dd	D	28	26	− 4	+16	−10	− 4	+42	+11	−24	−19	− 4	− 4	84	54
Ee	D	140	108	+ 5	− 5	− 3	+ 7	+ 9	+20	−10	−16	− 1	− 6	28	54
Ff	N	55	20	− 4	− 4	+22	+ 6	0	+21	+14	−24	+12	+ 1	52	56
Gg	D	91	94	− 3	− 2	−11	− 9	+26	+24	− 9	−20	− 3	+ 7	52	62
Hh	D	114	92	− 1	− 1	−17	− 5	+42	+36	−21	−17	− 1	− 3	82	62
Ii	N	48	42	+12	+20	+ 2	+12	−18	− 8	0	−20	+ 4	− 4	36	64
Jj	N	32	33	+ 8	− 4	−14	+ 4	− 7	−24	+ 7	0	+ 6	+24	42	66
Kk	D	102	82	− 4	+ 4	−17	− 4	−15	−10	+10	−19	+26	+29	72	66
Ll	N	64	81	+ 7	+11	−10	−14	−18	−22	+ 4	+ 1	+17	+24	56	72
Mm	N	51	22	+ 2	+10	+10	−10	−22	−26	+ 5	+16	+ 5	+10	44	72
Nn	N	70	65	+15	+21	+22	+11	−21	−24	−20	−15	+ 4	+ 7	82	78
Oo	D	77	97	−10	− 4	− 4	−19	+32	+40	−15	−16	− 3	− 1	64	80
Pp	D	53	33	− 2	+11	− 9	+ 4	− 9	−24	+ 2	− 5	+18	+36	40	80
Qq	D	92	83	+ 6	+ 5	+ 8	+16	+ 1	+ 3	−16	+20	− 1	−44	32	88
Rr	N	83	72	− 1	+ 9	+24	+36	− 1	−21	−24	−20	+ 2	− 4	52	90

The tabulation shows that eighteen out of the forty-four instructors considered have a less deviation the second semester

than the first and while this may be some fruits of the report, mere chance may have had more influence than the report.

Summarizing the three studies one can conclude that:

1. It is unjust to all concerned to award school honors and class distinctions on the personal judgment standard of teachers.
2. Personal judgments in their variation play a very great part in the fluctuation of the student's work. The lap-joint and handwriting were constant factors, yet the grades fluctuated, and this fluctuation is often considered as being due to student ability.
3. Rank placement is a much better indication of progress and is less likely to err than a percentage basis.
4. When the curve of distribution for the entire group is made known from time to time, the individuals approximate more closely this curve.
5. A mere presentation of facts, showing irregularity in grading, is not sufficient to change instructors from the haphazard and easy going methods of expressing personal judgments to a more scientific and exacting method.

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AMBIGUOUS DIRECTIONS.

What the book said: "Pour a little water into the bottle of ammonia gas, and shake, holding the hand over the mouth."

THE STATUS OF THE SCIENCES IN NORTH CENTRAL HIGH SCHOOLS IN 1916.

HARRY A. GREENE,

State University of Iowa, Ames, Ia.

The remarkable growth of the American high school in the past half century has brought with it a number of educational problems which administrators of the public schools must face. Prominent among these problems is the high school science situation. Recent years have seen a number of investigations in the field of high school science, but they have largely been studies of a single subject limited to a small field. So far as the writer is aware, no attempts have been made to make a comparative study of various high school sciences in a large number of high schools.[1]

It was with this purpose in mind that the writer undertook such an investigation in the fall of 1916. The study was made in full appreciation of the shortcomings of the questionnaire method, but the necessary data could not be secured in any other way. The data from which the summaries offered herein were compiled were obtained from replies to a questionnaire sent to the principals of 391 high schools of the North Central Association. One hundred and fifteen replies were received, one hundred and one of which were usable. The remainder of the work was merely the task of subjecting the data obtained to statistical treatment.

The schools were classified into groups according to the high school enrollment, and tabulations were made on that basis. That is, the purpose was to determine the central tendency for the various sciences in the different sized schools, as well as the general movements in all the schools reporting. High schools enrolling less than 100 pupils were known as Group A; those enrolling between 101 and 200 pupils were known as Group B; etc. Group K was composed of all those schools enrolling more than 1,000 pupils.

The nine commonly appearing high school sciences, viz., agriculture, biology, botany, chemistry, general science, physics, physiology, physiography, and zoology were considered from the following standpoints:

1. Frequency of appearance in high school curricula.

[1]Note.—Since writing the above the writer's attention has been called to a study by Prof. Koos of the University of Washington, on the status of all the high school subjects in the high schools of the North Central States. His findings with respect to the high school science situation corroborate our own.

2. Frequency of requirement of subject for graduation from high school.
3. Relative size of classes in subjects.
4. Length of courses offered.
5. Year in which subjects are offered.
6. Experience, training, sex of teachers of sciences.
7. Library equipment for subject.
8. Laboratory work and equipment.

Table I shows in summarized form the percentages of frequency of appearance of the nine sciences in all sizes of schools reported. Table I should be read as follows: 55.3 per cent of the 101 schools whose reports were used offer agriculture, and 16 per cent of the schools offering it require it for graduation from high school; etc.

TABLE I.

Subject	A	B
Agriculture	55.3%	16.0%
Biology	28.7	13.9
Botany	66.3	11.5
Chemistry	82.1	33.3
General Science	52.4	28.3
Physics	95.0	42.7
Physiography	61.3	12.9
Physiology	46.5	17.02
Zoology	35.6	14.3

A. Percentage of schools replying offering subject.
B. Percentage of schools offering subject requiring it for graduation.

It is evident that this table fails to take into account the variation in frequency of appearance of the subjects from group to group. For example, agriculture, which appears with a high percentage of frequency in the medium sized schools, appears with a low frequency in the larger schools. From this table, however, we are able to see at a glance the relative importance of the nine sciences from the point of view of frequency of appearance. On this basis the subjects rank as follows: Physics, chemistry, botany, physiography, agriculture, general science, physiology, zoology, and biology.

TABLE II.

Subject.	Year Offered.	Med. Class for Year.	Med. Class Enrollment.	S.	I.	R.	Per Cent.	Rank.
Agriculture	3	42	24		9		57.0	4
Biology	2	59	18		8		30.5	9
Botany	2	59	41		25		69.9	3
Chemistry	3	42	34		12		81.0	1
General Science	1	88	45		19		51.0	5
Physics	4	33	25		15		79.0	2
Physiography	1	88	36		32		40.5	6
Physiology	1	88	29		19		33.0	8
Zoology	2	59	22		22		37.0	7

Table II shows for each subject the year in which it is offered, the median for the total size of the class for the year in which

it is offered, the median enrollment in the subject with the semi-inter-quartile-range given, the percentage that the median enrollment in the subject is of the total size of the class for the year in which it is offered, and the rank of the subjects on this basis. Table IV of this paper offers the basis for determining the year in which the subjects are offered. The median sizes of first, second, third and fourth year classes was determined from percentages given on page 487 of the Commissioner of Education's Report for 1916. The average percentage for each of the four high school classes for the North Central States was found, and the median class found on the basis of the median enrollment of all the schools reporting for this study, which was 222 pupils. The semi-inter-quartile-range is found by taking one-half the difference between the first and third quartiles of the array, and means the distance on either side of the median it will be necessary to go in order to include 50 per cent of the cases. Table II is read as follows: Agriculture is most often offered in the third year of the high school course. Over 50 per cent of the class enrollments fall between 15 and 33 pupils. The median size of the third year high school class is 42 pupils. Fifty-seven per cent of the median third year high school class is enrolled in agriculture, and on this basis agriculture ranks fourth among the nine sciences; etc.

There are certain quite well defined tendencies in the matter of the length of the science courses. Some, such as zoology, and physiology, are obviously one semester courses; others, as botany, chemistry, and physics are just as definitely classified as two semester courses. Table III shows this situation clearly in terms of percentages.

TABLE III.

Subjects	Semesters One	Two	Three	Four	Six	Eight
Agriculture	30.8%	49.8%	1.8%	9.1%	1.8%	7.3%
Biology	25.0	75.0				
Botany	53.7	44.8	1.5			
Chemistry	1.2	95.1	1.2			
General Science	35.8	64.2				
Physics	2.2	95.6	2.2			
Physiography	57.9	42.1				
Physiology	80.4	19.6				
Zoology	80.0	17.1				

This table is to read as follows: 30.8 per cent of the 101 schools reporting offering agriculture offer it for one semester; 49.8 per cent offer it two semesters; 1.8 per cent offer it three semesters; 9.1 per cent offer it four semesters; etc.

TABLE IV.

Subjects	Year First	Second	Third	Fourth
Agriculture	17.7%	26.2%	33.3%	21.4%
Biology	16.6	76.7	6.6	
Botany	26.9	55.1	12.9	5.1
Chemistry	1.1	2.2	49.1	47.6
General Science	96.2	3.7		
Physics	.9	1.8	38.4	57.8
Physiography	59.1	23.9	5.6	11.2
Physiology	43.1	15.7	29.4	11.8
Zoology	6.8	68.2	18.1	6.8

From Table IV it is evident that, with the possible exception of general science, the year in which the sciences are offered is not well fixed in practice. Agriculture is almost equally divided between the four years; biology is quite definitely located in the second; chemistry and physics are evenly divided between the third and fourth years, etc.

From the data shown in Table V it appears that in general male teachers of the sciences are more popular than female teachers. In only two cases of the nine sciences listed do we find the percentage of male teachers of the subject falling below 50 per cent, and in only one subject, zoology, do we find the percentage of female teachers exceeding the percentage of male teachers. For the female teachers the median is 43.3 per cent, for the male teachers the median percentage is 60.0 per cent; showing a decided tendency in favor of the latter.

TABLE V.

Subjects	Percentage Teachers M.	F.	Avg. Yrs. Experience M.	F.	Sem. Hrs. Training M.	F.
Agriculture	91.1%	7.1%	3.2	2.8	10	24
Biology	55.6	40.1	3.0	7.0	14	30
Botany	51.4	47.1	7.5	6.8	14	16
Chemistry	88.6	11.4	6.6	7.0	21	15
General Science	74.0	20.8	2.4	2.4	12	
Physics	89.9	11.1	8.0	6.6	17	15
Physiography	55.4	41.5	4.1	5.8	10	12
Physiology	48.9	44.8	3.7	4.8	8	3.5
Zoology	38.2	50.0	4.8	5.7	9	19

The average years of experience in teaching the science subjects ranges, for men from 2.4 years for general science to 8 years for physics. The median years experience for men is 3.5 years. For women, the lower limit is the same as for men for general science, but goes up to only 7.0 years for both biology and chemistry. The median number of years experience for women is 6 years. Along with this may be noted the fact that the median number of semester hours college preparation in the subjects for all female teachers of the sciences listed is 15.5 hours, as

contrasted with 12 hours, the median for male science teachers. It is thus apparent that while male teachers are found in the science positions with a slightly greater frequency, the female teachers are better prepared to teach the subjects, if college training is an indication of preparation to teach a subject. Female teachers are also more experienced in teaching science, or at least remain in that field longer than do male teachers.

TABLE VI.

Subjects	Median Value	Semi-inter-quartile-range
Agriculture	$27.80	$10.50
Biology	15.00	15.00
Botany	23.50	26.00
Chemistry	28.50	24.00
General Science	12.00	9.00
Physics	26.65	30.00
Physiography	18.00	7.00
Physiology	9.00	7.00
Zoology	32.00	51.00

Library equipment in the special science subjects is, unfortunately, not very extensive in the schools reporting for this study. Because of the extremely wide range in a number of the cases the medians given appear to be of questionable value, but, when limited by the semi-inter-quartile range, do serve to give us the central tendency with respect to library equipment. The sciences having libraries valued at more than the median for all libraries are: agriculture, botany, chemistry, physics, and zoology. The remaining sciences, biology, general science, physiography, and physiology, have values lying below the medians for all subjects.

The number of volumes in the special libraries varies from 10 to 25. The median number is 17 volumes. The following subjects have libraries larger than the median: agriculture, botany, chemistry, physiography, and zoology. The remaining four sciences, biology, general science, physics, and physiology, have libraries smaller than the median.

TABLE VII.

Subjects	Median Value of Lab. Equipment	Semi-inter-quartile-range
Agriculture	$205.00	$ 94.00
Biology	400.00	330.00
Botany	270.00	62.50
Chemistry	550.00	500.00
General Science	120.00	225.00
Physics	950.00	500.00
Physiography	100.00	132.00
Physiology	75.00	55.00
Zoology	125.00	262.50

The median values of laboratory equipment for the sciences

range from $55.00 for physiology up to $900.00 for physics. In a few cases the semi-inter-quartile range is quite wide, however, in the majority of cases the medians are quite reliable. If they are reliable they are certainly significant of the status of the subjects. Ranked according to the values of the laboratory equipment the subjects are as follows: physics, chemistry, biology, agriculture, zoology, general science, physiography, and physiology. The median value of all laboratory equipment in all subjects reported is $200.00 with a median deviation of $100.00.

TABLE VIII.

Subjects	Median No. of Lab. Expts. Attempted	Semi-inter-quartile-range
Agriculture	46	16
Biology	38	15
Botany	31	11
Chemistry	60	5
General Science	33	14
Physics	45	5
Physiography	15	8
Physiology	18	5
Zoology	24	11

The amount of laboratory work in the different sciences is undoubtedly indicative of the status and importance of the subject, but just to what extent it is indicative is hard to determine. In general, it appears that the sciences that have ranked high from other points of view, also rank high when considered from this standpoint. It is evident that we are taking a liberty when we use the term "experiment" as a unit, for certainly an "experiment" in chemistry is not necessarily the equal of an "experiment" in physics or in zoology. However, the median number of experiments attempted for each science is shown in the above table. Ranked on this basis the sciences are as follows: chemistry, agriculture, physics, biology, general science, botany, zoology, physiology, and physiography. Those sciences above general science in the list are either on or above the median for all.

The attempt to determine the final ranking of the sciences seems best made by comparing the various subjects from a number of points of view from which they have been treated in this paper. Table IX shows the results of such an attempt.

TABLE IX.

Subjects	I	II	III	IV	V	VI	Total	Final
Agriculture	5	5	4	3	5	2	24	3
Biology	9	7	9	7	3	4	39	7
Botany	3	9	3	5	4	6	30	4

Chemistry	2	2	1	2	2	1	10	1
General Science	6	3	5	8	7	5	34	5
Physics	1	1	2	4	1	3	12	2
Physiography	4	8	6	6	8	9	41	8
Physiology	7	4	8	9	9	8	45	9
Zoology	8	6	7	1	6	7	35	6

I. Rank of subjects in percentage of frequency of appearance.
II. Rank of subjects in percentage of frequency of requirement for graduation from high school.
III. Rank of subjects in terms of percentages of pupils in high school classes (year) enrolled in subjects.
IV. Rank of subjects in terms of the value of library equipment.
V. Rank of subjects in terms of laboratory equipment.
VI. Rank of subjects in terms of number of laboratory experiments attempted.

The six ranks used in this table were taken directly from the preceding tables and represent the points of view from which it seemed legitimate to compare the subjects. It is obvious that the data included in Tables III and IV were not usable for this purpose. It is just as obvious that to rank the sciences on the basis of the percentage of male teachers employed would be of slight value, for the mere inclusion of the rank of the sciences on the basis of the percentage of female teachers employed would make it possible to manipulate the final rank at will, so such variable data were not included in the attempt to determine the final rank of the sciences. The fact that there is a high correlation between the value of libraries and the number of volumes in them made it necessary to include only one factor on that point.

The final rank of the high school sciences on the basis of the six points given above is as follows:

1. Chemistry.
2. Physics.
3. Agriculture.
4. Botany.
5. General Science.
6. Zoology.
7. Biology.
8. Physiography.
9. Physiology.

The following table of intercorrelation is given merely to show the relation of each factor used in determining the rank to every other factor and to the final rank.

TABLE X.

	Intercorrelations—Spearman						
Rank in	I	II	III	IV	V	VI	Final
I		.25	.7	.18	.4	.18	.4
II			.25	.03	.33	.25	.4
III				.33	.4	.48	.7
IV					.33	.25	.48
V						.55	.63
VI							.63

A STUDY OF THE ATTAINMENTS OF HIGH SCHOOL PUPILS IN FIRST YEAR CHEMISTRY.[1]

By J. Carleton Bell,

Brooklyn, New York, Training School for Teachers.

Introduction—Experimental Studies of the Results of Teaching.

There is a growing realization of the need for careful and accurate studies of the methods and results of teaching. In all lines it is recognized that too much dependence has been placed on inspiration and faith, and too little scrutiny has been given to results. It is especially incumbent upon teachers of science to make an application of the experimental methods which have been their boast in nature studies to the problem of determining the results of their own teaching.

Early attempts at measuring the attainments of pupils in school subjects were confined to the elementary branches. In arithmetic Rice in 1902 devised pioneer tests in the endeavor to determine whether the large amount of time devoted to the subject in some schools gave commensurate returns in increased performance. He concluded that it did not. Stone followed in 1908 with a more carefully analyzed series of tests in fundamentals and problems, and confined his attention to the study of the arithmetical abilities of sixth-grade pupils. Courtis in 1910 and 1914 devised two series of tests for measuring arithmetical attainments, and through his Bureau of Cooperative Research has secured records from thousands of children. Finally, Woody in 1916 derived a scale for measuring the achievements of pupils in the fundamental arithmetical operations.

In spelling, the studies of Rice, Cornman, and Wallin opened up the field and prepared the way for the more accurate investigations of Buckingham, who determined statistically the relative spelling difficulty of 180 words, and of Ayres, who selected the 1,000 words most commonly used in writing and arranged them in a scale of twenty-six equal steps of spelling difficulty. In handwriting, we have the Thorndike and the Ayres scales, the Freeman standard measurements, and the Gray score card. Many cities (notably, New York) are now constructing their own scales for the measurement of handwriting. In drawing, there is the Thorndike scale, with the Childs extension, and the

[1]Read before the Chemistry Section of the Central Association at Columbus, Ohio, December 1, 1917.

Rugg scale for free-hand lettering. Several studies have been made in geography, and in reading we have the Starch tests, the Thorndike scales, the Brown test, the Kansas tests, and the Gray scales for the measurement of oral and silent reading. From this hasty survey it will be seen that measurements of the attainments of pupils in elementary subjects are multiplying apace, and it may be confidently stated that they are already having their effect on both the subject matter and the methods of elementary school work.

When we turn to the high school field we find less to chronicle. In algebra, Monroe, Childs, and Rugg have constructed promising tests for the work of the first year; in Latin, Hanus carried on a preliminary investigation of vocabulary, H. A. Brown has much unpublished material on translation from Latin into English, and Henmon has published in the *Journal of Educational Psychology* carefully constructed scales for the measurement of Latin vocabulary and Latin translation; in geometry, Stockard and Bell studied the responses of 372 pupils to a representative list of questions; in history, Bell and McCollum investigated the attainments of 1,500 pupils in United States history, and Sackett has proposed a scale for the ancient period; and in zoology Gilbert reported an experiment on methods of teaching the subject. Mann has for some time been engaged in an elaborate investigation of engineering education, and has devised some ingenious tests for students of physics, but so far as the writer knows has published nothing on the subject. Mayman made an interesting experimental study of the relative values of the textbook, lecture, and laboratory methods of teaching physics to seventh-and eighth-grade boys.

The work of Gilbert, as the only published experimental investigation in the teaching of any of the natural sciences to secondary school pupils, is worthy of somewhat more extended notice. Gilbert's problem was to ascertain whether the pure science or the applied science method of attack gave better results in teaching elementary zoology to high school students. He divided his class of thirty-two pupils (how we are not told) into two almost equal sections. Each of these sections was given the same subject matter, but in Section A emphasis was laid on analysis and description, after the approved fashion in elementary zoology, while in Section B, in addition to the strictly zoological study, stress was placed on the economic significance

of the animals considered. At the end of the term both sections were given the same test, which was constructed from the point of view of pure zoology. The applied science section made slightly the better showing. In tests of ability in experimentation and interpretation the applied science section was distinctly superior. The author concludes that the results of the experiment favor the applied science rather than the pure science method for high school pupils.

The only consideration thus far given, within the knowledge of the writer, to a scientific study of the teaching of chemistry is in an article by Ellwood B. Spear, entitled, "Problems in the Experimental Pedagogy of Chemistry." Spear assumes that the chief value in teaching chemistry to high school pupils lies in the general mental training it affords, and suggests problems to determine to what extent the general traits of manipulation, observation, correlation of ideas, logical reasoning, imagination, and the spirit of investigation are developed by the study of chemistry. But modern psychology bids us be very chary about accepting the existence of such broad general faculties. It is open to question whether there is any such thing as a general power of observation. Certainly, improvement in the observation of chemical reactions would scarcely be expected to improve one's observation of fine paintings, or of the fall of the cards in a game of whist. Before we are ready to investigate the *general* mental improvement which results from the study of chemistry, we need to know more about the improvement of pupils in chemistry thinking itself.

The Present Study.

A really adequate study of the attainments of pupils in chemistry would involve a series of tests to determine the natural intellectual abilities of each pupil before taking up the subject; a careful study of the previous training of each pupil; an exact record of the work of the course, including the topics taken up, the time devoted to each, the methods of presentation and study, the attitude of the pupil toward the work, and the personal influence of the instructor; a series of reliable tests at the end of the course to show the pupil's mastery of the subject; another series of tests after the lapse of a considerable time to indicate how much of the subject was retained; and a test of the readiness with which this knowledge could be applied to other chemical situations. The present study makes no pretense at any such completeness. It is a preliminary, tenta-

tive investigation, undertaken primarily to find out what Texas high schools were doing in chemistry, and what variations schools and individual pupils would show in response to the same set of questions. Incidentally, it was thought that the results might throw some light on the relative difficulty of various aspects of chemistry.

The first task was the selection of a list of questions that would be fairly representative of the field of first-year chemistry. A more objective method would have been to draw up a list of 200 or 300 questions covering all phases of elementary chemistry, and to submit these to experienced chemistry teachers in different parts of the country with the request that they arrange them in the order of their importance. Such a procedure, however, would have required much time, and in the present instance it was thought advisable to act at once. After a careful study of the leading texts in elementary chemistry and an analysis of their contents, twenty-five questions were chosen as covering the more important and more generally considered topics of chemistry.[2]

The aim in the formulation of these questions was to select topics that were basic for elementary chemistry, to phrase the questions so that they could be answered briefly, and to call for such answers as would be either right or wrong. When the results came to be evaluated, however, a more satisfactory scoring was found to be one credit for answers approximately correct, one-half credit for those only partially correct, and zero for those quite beside the mark. At the top of the page the pupil was asked to indicate in appropriate blank spaces his name, the school, the date, the amount of chemistry instruction he had had, and the time when this work was taken. The questions were as follows:

1. What chemicals are liberated in electrolysis of water?
2. What gas is given off by the action of yeast in bread dough?
3. Name two chemicals used in making oxygen.
4. Express in cubic centimeters one litre.
5. Name two substances used in making hydrogen.
6. Define oxidation.
7. Define reduction.
8. Name four processes of purifying water.
9. What is a deliquescent substance?
10. Name two gases either of which might be used to bleach cloth or flowers.
11. Name two very common organic acids.

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[2]For this work the writer desires to express his obligation to Mr. R. G. Upton, an experienced teacher, who was at that time assistant in education in the University of Texas.

12. Name two chemical compounds used in making common salt.
13. Write the reaction for sulphuric acid on potassium hydroxide.
14. Name the two most abundant elements in the atmosphere.
15. Name two commercial sources of ammonia.
16. Is air a chemical or physical mixture?
17. Why does ammonia water always feel cold when it comes in contact with the hands?
18. Name substances used to make aqua regia.
19. Name four basic hydroxides.
20. Name the commercial uses of the nitrates.
21. What are the properties of carbon bisulphide?
22. Give chemical name of $CaSO_4$ ....., H_2S ....., Na_2SO_3 .....
23. What is the valence of H ....., of O ....., of Ca ....., of SO_4 .....
24. Name the members of the chlorine group.
25. How many grams of water are formed by the combustion of 10 grams of hydrogen in the air? (Work on this paper.)

Returns were received from chemistry classes in 16 of the leading high schools of Texas. They included papers from 401 pupils. In 14 of these schools the pupils (337 in number) had studied chemistry for eight months. These results were grouped together and form the chief basis for the present discussion. In one school the study had been carried on only three months, while in another school results were obtained from two classes, one of which had studied chemistry for three months, and the other, an advanced class, had studied the subject for twelve months. The number of pupils in these classes ranged from 10 to 50, with an average of 24.

Unfortunately, no data were secured as to the method of conducting the work in chemistry, the textbooks used, the number of sections in a class, the number of recitations per week, the amount and character of laboratory work, the extent of laboratory equipment, or the topics emphasized in the course. The scores, therefore, have to stand as bare results, with no supplementary material for interpretation.

The Results.

This is not the place for the presentation of statistical tables. These will be found in the special science number of the *Journal of Educational Psychology*, published in April, 1918. Here it must suffice to indicate the general features of the returns. The scores were tabulated to show the response of each pupil to each question. The total score of each pupil was determined and expressed in per cents of a perfect score. The average of these per cents was taken as the index of the school, and the average of these indices gave the status of the entire group. Further, the percentage of correct responses made by each school to each question was computed, and these were

combined to show the relative familiarity of each question. The results from the 14 schools whose pupils had studied chemistry for eight months will first be considered. The average scores for these schools range from Lockhart (14 pupils), 81 per cent; Brownwood (18 pupils), 75 per cent; Coleman (15 pupils), 69 per cent; and Fort Worth (50 pupils), 69 per cent; to Uvalde (10 pupils), 45 per cent; Garland (16 pupils), 45 per cent; and San Marcos (28 pupils), 36 per cent. The average for the entire group of schools was 59 per cent. It will be noted that the ratio of the extremes is well below 1 to 2, and that size of school seems to have no connection with grade of performance. The Lockhart school had 100 per cent correct on six questions, 75 per cent or better on sixteen questions, and the lowest question received 29 per cent. In the San Marcos school the highest score on a question was 86 per cent, the next highest was 70 per cent, seven questions received scores of less than 10 per cent, and two questions had 0 per cent. Thus the difference between the two schools was a uniform one and did not depend on the responses to a few questions.

The highest individual scores were made by two boys in the Dallas high school (46 pupils). Their scores were 100 per cent and 98 per cent, although the average of that school was only 63 per cent. The lowest scores were made by three boys in the San Marcos high school, 16 per cent, 18 per cent, and 18 per cent. The Beeville high school (23 pupils) showed the greatest extremes, ranging from 90 per cent to 18 per cent (boys in both cases), with an average of 56 per cent. Denton high school (18 pupils) had one boy who got 94 per cent, while two Lockhart boys received 94 per cent and 92 per cent respectively. In almost all the high schools the range of scores was very wide, running usually from the thirties to the eighties. Exceptions to this were Lockhart, where the range was 94 per cent to 66 per cent; Brownwood, 88 per cent to 66 per cent (showing the least variation of all), El Paso (21 pupils), 84 per cent to 46 per cent; Mexia (21 pupils), 70 per cent to 28 per cent; Garland, 70 per cent to 24 per cent; and San Marcos, 62 per cent to 16 per cent.

In addition to the 14 schools whose pupils had had eight months of chemistry, reports were received from 36 pupils in the San Antonio high school, who with only three months' instruction made an average score of 58 per cent, range 86 per cent to 30 per cent. In the Galveston high school were two

classes of 14 pupils each. The advanced class had had twelve months of chemistry, and made an average score of 76 per cent, range 86 per cent to 50 per cent. The elementary class had had only three months of chemistry and its average was 36 per cent, range 54 per cent to 20 per cent.

From these figures it is obvious that there are striking differences in the work done by the various schools. San Antonio probably makes the best showing, since in three months' time an average score is obtained which is within one point of the average for all of the eight-months' pupils. In the same time of three months, Galveston only does as well as the poorest of the eight-months' schools, and in twelve months it does not come up to the best of the eight-months' group. The figures are to be commended to the principals and teachers of these schools for a careful examination of the question whether their time is being used to the best possible advantage.

A special tabulation of the results from boys and girls was made for each school. Of the entire 401 pupils, 199 were boys and 202 were girls. On the whole the numbers were fairly equal in the several schools, the greatest discrepancies being found in Coleman (3 boys and 12 girls), and Denton (14 boys and 4 girls). As already pointed out, all the highest and lowest scores were made by boys, the girls' scores occupying an intermediate position. On the average the boys were distinctly superior to the girls, the boys scoring 62 per cent, the girls 56 per cent. This superiority of the boys was found in 13 out of the 17 classes, and is thus quite uniform.

Not only were the individual and class scores on the entire test computed, but the percentage of correct responses was determined for each school on each question. A detailed discussion of these results would lead us too far for the present occasion. We may note that on the basis of the 14 schools in our main group, Question 1 (electrolysis of water) was the most familiar, with an average of 93 per cent. Next in order come Question 2 (yeast in bread) with 90 per cent, Question 24 (the chlorine group) with 85 per cent, Question 5 (making hydrogen) and Question 19 (basic hydroxides) with 77 per cent each, Question 14 (elements in atmosphere) with 75 per cent, Question 10 (bleaching gases) with 71 per cent, and Question 23 (valence of H, O, Ca, and SO_4) with 70 per cent. It is interesting to note here that the composition of water and the action of yeast are almost equally well known, that there is a distinct drop to the

chlorine group, and a still greater drop to the basic hydroxides, and that the responses to the other questions fall fairly close together.

On the other hand, the least known was Question 15 (commercial sources of ammonia) with 20 per cent, followed by Question 21 (properties of carbon bisulphide) with 22 per cent, Question 25 (amount of water from the combustion of 10 grams of hydrogen in the air) with 28 per cent, Question 20 (commercial uses of nitrates) with 33 per cent, Question 17 (why does ammonia feel cold) with 35 per cent, Question 9 (deliquescent substance) and Question 12 (compounds used in making common salt) with 50 per cent each, and Question 11 (two common organic acids) with 54 per cent. The gap here between the first five and the last three (35 per cent to 50 per cent) is striking. The percentages for the remaining nine questions are grouped about the average, 59 per cent. It is interesting to observe that Question 3 (two chemicals used in making oxygen), Question 4 (number of cubic centimeters in one liter), Question 6 (oxidation), Question 7 (reduction), Question 8 (four processes for purifying water), Question 18 (substances used in making aqua regia), and Question 22 (chemical names of $CaSO_4$, H_2S, and Na_2SO_3) lie within 5 per cent of each other (58 per cent to 63 per cent).

It is obvious that the present study is a preliminary and local one. It justifies the contention, however, that such studies, amplified and extended, would contribute greatly to the teaching of chemistry. They would afford a means of comparing with some degree of objectivity the work done in different schools. They would soon furnish material for the construction of a scale in chemistry by which it would be possible to determine quickly and accurately the extent of any pupil's attainments in the subject. The prosecution of such studies is urgently demanded of progressive superintendents, principals, and high school teachers of chemistry in this country.

The special campaigns in the South for the increased production of foodstuffs through the extension forces resulted in a marked increase in the planting of corn, soy beans, velvet beans, cow-peas, peanuts, sweet potatoes, Irish potatoes, and other food crops. The corn crop in the fifteen Southern States was 964,504,000 bushels, or more than a fourth of the whole crop of the United States.

THE GRAPHICAL SOLUTION OF PROBLEMS.

By Paul H. Geiger,

Ann Arbor, Mich.

In the November, 1917, number of School Science and Mathematics appears a paper, entitled, "Two Uses for Graphs." The first part of this article is concerned with the equation used in solving elementary problems about lenses and mirrors, and the author after presenting a graph of that equation shows how to obtain the approximate numerical answers to typical problems. The graphical method thus set forth has certain pedagogical advantages, in that the subject material is clearly and simply displayed. But the numerical results may be obtained, without calculation, by other methods which are sufficiently general to warrant their value and interest. They were brought to the author's attention by Mr. Herbert Bell. The first is an extension of the idea of the slide rule. The second is a very simple example of the straight line nomogram.

In an ordinary slide rule the addition of logarithms is facilitated by two parallel and similar scales which, when they are properly displaced, give a product, just as a sum may be obtained by two ordinary yardsticks. The essential feature of the instrument is that while the ordinary numbers appear along the scales, the distance out to them is proportional, not to the number, but to its logarithm. Such a rule does not help us much with the equation,

$$\frac{1}{p} + \frac{1}{q} = \frac{1}{f}.$$

But if the scale were so constructed that the distance from

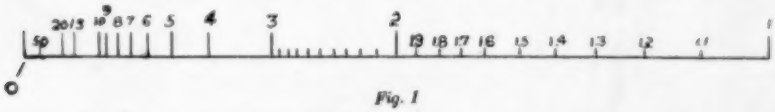


Fig. 1

the origin to any number was proportional to the reciprocal of that number, then two such scales, side by side, would solve a problem of our particular class, just as the ordinary rule gives us a product. Such a scale appears in Figure 1. With a pair of dividers, problems may be solved with this scale alone. For, supposing p is 6 and q is $+2$, we can with the dividers add the reciprocal of 6 to that of 2, giving the reciprocal of 3/2, which is f. Two such scales, side by side, would be operated just as the ordinary slide rule. The scale may be constructed by actual

computation and measurement, but more simply by projection as is shown in Figure 2. Here the scale of reciprocals appears along AB, natural numbers being set down along CD, and O being the center from which lines are drawn.

Evidently, if Dr. Sleator had laid off scales of reciprocals along his axis and then plotted his curve, it would have been a straight line. Evidently, also, the method is not limited in its application to this one type of problem, but suitable scales may be constructed for any equation expressing an additive relation between simple functions. In case the equation to be solved contains a product or a quotient, one obtains by passing to logarithms a new equation which contains an algebraic sum, thereby permitting suitable scales to be constructed.

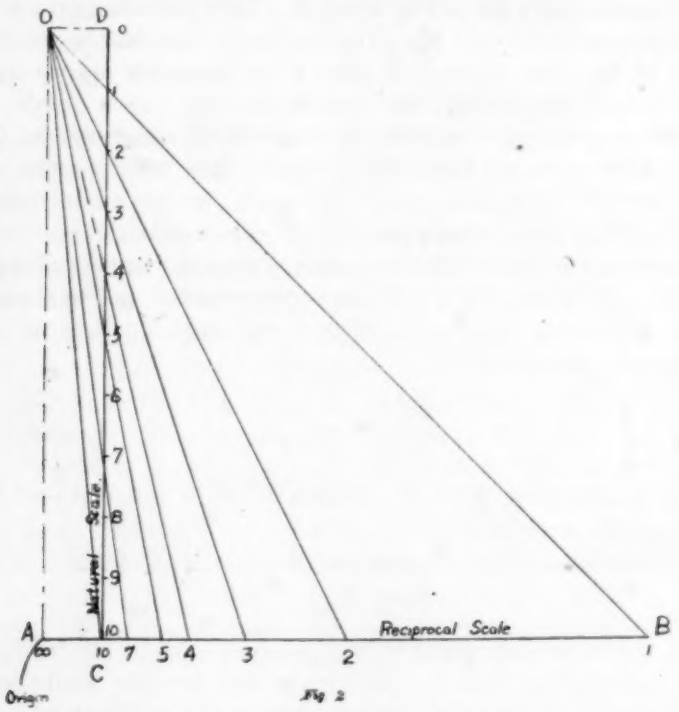


Fig 2

The second method is that of the straight line nomogram. No attempt will be made to give the theory of the nomogram, only a single application which, though originally obtained by using the general method of the nomogram, is so simple that it can be understood without any knowledge of the theory.

The formula,

$$\frac{1}{p}+\frac{1}{q}=\frac{1}{f}$$

may be written

$$\frac{1/p+1/q}{2}=\frac{1}{2f} \qquad \text{(equation B)}.$$

On two parallel straight lines EB and E′B′ (Figure 3) are laid off scales of reciprocals as explained under the first method, with the exception that the distances are laid off in both directions from the origins O and O′ instead of in one direction only. Let AC be a line midway between EB and E′B′ and parallel to them. Now if p and q are known we may connect point P (Figure 3) on EB (where the distance OP represents the reciprocal of p) with point Q on line E′B′ (where the distance O′Q corresponds to the value of the reciprocal of q) by a straight line PQ. The distance FD between the intersection of this line with AC and the origin then represents the average length of AC, OP and O′Q, which in mathematical terms is

$$\frac{1/p+1/q}{2}.$$

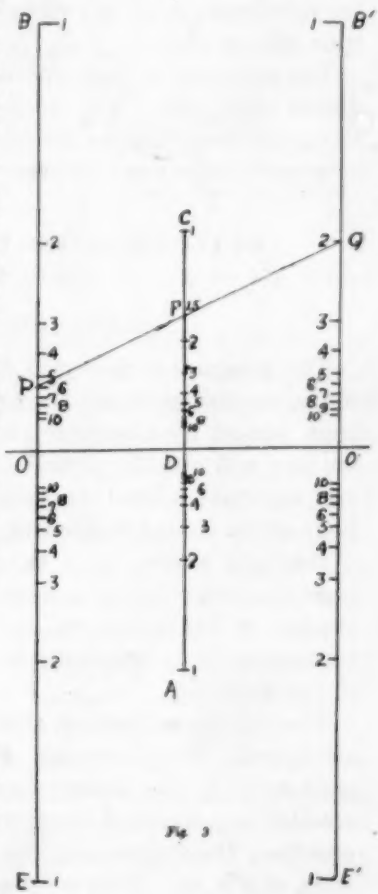


Fig. 3

This by equation B is equal to $1/2f$, so if we lay off on line AC scales similar to those on EB and E′B′ but with the unit only one-half as great, we may read directly the solution. Letting EB be the p axis, AC the f axis, and E′B′ the q axis, we can find either p, q, or f when the other two are given. This is done by laying a straight edge across the two known points on their

corresponding axes and reading the unknown value on the remaining axis. When values are negative, the distances are to be measured below (or to the left of, in case the lines are horizontal) the line OO′.

It is evident that the use of these methods would be extremely limited in case only problems having values which are shown on the scale, can be solved. However, in the calculations we may disregard the decimal point and therefore our scales will apply to any values. The location of the decimal point in the answer is usually obvious; if not it may be determined by easy approximations, as it is determined when the ordinary form of slide rule is used.

The accuracy of these methods is the same as that of an ordinary slide rule. With scales a foot long, results accurate to three significant figures may be obtained; with longer scales the accuracy can be made as great as we may desire.

DAYLIGHT SAVING IN THE UNITED STATES.

By W. M. Gregory,

Teachers College, Cleveland, Ohio.

The geography class will find much material for discussion in the provisions of the Daylight Saving Act which has recently been passed by Congress and signed by the President. The student will quickly perceive that this bill is a national affair, and also that a legal status is given the various standard time belts of the United States and Alaska.

Daylight saving, in a nutshell, is to advance the standard time one hour during a period of five months every year, beginning at 2 o'clock a. m. of the last Sunday in March, and retarding one hour beginning at 2 o'clock a. m. of the last Sunday in October.

There is no suggestion that hours of work be lengthened or shortened. The shortening of the old-time work day of "sun-up to sunset" to the present day of ten hours or eight hours, has resulted in a waste of the morning sunlight hours in the summer months. On a June day the sun rises at 4 a. m. and we start work at 8 a. m. Thus we sleep through hours of sunlight in the morning and have our period of recreation at the close of the day in artificial light. We waste the daylight and use the artificial light and heat which could easily be conserved if this measure became a law.

The practical value in the conservation of daylight has been fully established where this plan is in operation in Austria, Denmark, France, England, Italy, Holland, Norway, Portugal, and Sweden.

If the student will plat the time of sunrise and sunset for his locality for the entire year, he will readily see how the daylight is thrown away and the artificial light substituted. The Nautical Almanac will give all the necessary data for such a graph. Let the student figure the saving in the electric light bill in his family and city. Careful estimates give $40,000,000 as the amount to be saved in this country in a single year by this plan. France is believed to have saved $10,000,000 each year by this plan, and England about $12,000,000. There is not much but the inertia of tradition to be urged against daylight saving.

The entire provisions of the Daylight Saving Act are to be found in the following paragraphs. From a reading of this act and the graph of daylight and night, have the pupil explain the reason for the change of time in March and October.

THE DAYLIGHT SAVING ACT.

To Save Daylight and to Provide Standard Time for the United States.

Section 1. *Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,* That, for the purpose of establishing the standard time of the United States, the territory of continental United States shall be divided into five zones in the manner hereinafter provided. The standard time of the first zone shall be based on the mean astronomical time of the seventy-fifth degree of longitude west from Greenwich; that of the second zone on the ninetieth degree; that of the third zone on the one hundred and fifth degree; that of the fourth zone on the one hundred and twentieth degree; and that of the fifth zone, which shall include only Alaska, on the one hundred and fiftieth degree. That the limits of each zone shall be defined by an order of the Interstate Commerce Commission, having regard for the convenience of commerce and the existing junction points and division points of common carriers engaged in commerce between the several states and with foreign nations, and such order may be modified from time to time.

Section 2. That within the respective zones created under the authority hereof the standard time of the zone shall govern the movement of all common carriers engaged in commerce between the several states or between a state and any of the

territories of the United States, or between a state or the territory of Alaska and any of the insular possessions of the United States or any foreign country. In all statutes, orders, rules, and regulations relating to the time of performance of any act by any officer or department of the United States, whether in the legislative, executive, or judicial branches of the Government, or relating to the time within which any rights shall accrue or determine, or within which any act shall or shall not be performed by any person subject to the jurisdiction of the United States, it shall be understood and intended that the time shall be the United States standard time of the zone within which the act is to be performed.

Section 3. That at two o'clock antemeridian of the last Sunday in *March* of each year the standard time of each zone shall be advanced one hour, and at two o'clock antemeridian of the last Sunday in *October* in each year the standard time of each zone shall, by the retarding of one hour, be returned to the mean astronomical time of the degree of longitude governing said zone, so that between the last Sunday in *March* at two o'clock antemeridian and the last Sunday in *October* at two o'clock antemeridian in each year the standard time in each zone shall be one hour in advance of the mean astronomical time of the degree of longitude governing each zone, respectively.

Section 4. That the standard time of the first zone shall be known and designated as United States Standard Eastern Time; that of the second zone shall be known and designated as United States Standard Central Time; that of the third zone shall be known and designated as United States Standard Mountain Time; that of the fourth zone shall be known and designated as United States Standard Pacific Time; and that of the fifth zone shall be known and designated as United States Standard Alaska Time.

Section 5. That all acts and parts of acts in conflict herewith are hereby repealed.

GARDEN INCREASE ESTIMATED TO BE AT LEAST TWO HUNDRED PER CENT.

The home-garden campaign of last spring and summer, part of the effort to increase the nation's supply of war-time food, stimulated, it is estimated, the planting of from two hundred to three hundred per cent more gardens than ever before had produced food in the United States in one season, according to the annual report of the Secretary of Agriculture, David F. Houston. This was particularly true in the South, where the work was a logical development of the "safe farming" program which has been advocated for several years.

RESEARCH IN BIOLOGY.

Conducted by Homer C. Sampson.

Ohio State University, Columbus.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be nontechnical, and it is hoped that they will furnish material that will be of value in the classroom. Suggestions and contributions should be sent to Dr. Homer C. Sampson, Department of Zoology, Ohio State University, Columbus, Ohio.

THE RELATION OF ECOLOGY TO HIGH SCHOOL BIOLOGY.

By Morris M. Wells,

The University of Chicago.

The problems relating to the teaching of biology in the high school are obvious to those who have attempted the task, and it will not be necessary for me to enumerate them in detail at this time. In general they are problems which may be grouped into two classes, namely, problems pertaining to the organization of the course, and those having to do with the securing of sufficient and suitable material for the class and laboratory work.

These two general groups of problems, which teachers of biology are attempting to solve everywhere are not peculiar to the subject of biology, but are characteristic of all the laboratory sciences. However, I do not believe that the high school curriculum contains any subject, the presentation of which is beset with greater difficulties, than those to be met with in the conducting of a real live course in botany or zoology, and, furthermore, I am inclined to believe that there are few, if any, of the other high school subjects, whose presentation demands as much of the teacher as do these two sciences. It not infrequently happens that the same instructor is called upon to conduct courses in both biology and either physics or chemistry. Those who have had their work thus distributed will, I believe, agree that, given equal training in the two branches of science, the nervous energy expended in their teaching efforts has been largely on the biological side of their program.

The difference in the demands made upon the teacher by the two types of science are due in part to the fact that physics and chemistry are older sciences and are, therefore, more highly organized than are the biological subjects. The textbooks used in either physics or chemistry have reached a high degree of standardization, as have also the materials and apparatus used in

the laboratory. One may choose his textbook of physics, and with practically no effort order from the supply house a complete set of apparatus designed especially for use with the text in question. This apparatus may be left on the storeroom shelves for months without danger of deterioration. With chemistry much the same thing may be done.

The biological sciences have not as yet been reduced to such a comfortable system, and perhaps never will be. It is not impossible that in the future one may order his biological supplies wholesale so to speak, but the very nature of the subject makes it undesirable that one should use biological supplies in the "canned or bottled" form. Biology is the study of life, and it is obvious that we cannot hope to understand or appreciate biological phenomena if we devote all our time to the study of dead organisms. Even though it be possible to purchase living laboratory materials, our knowledge is not broadened to the desired extent by studies made exclusively in the laboratory. Plants and animals cannot be treated in the same manner as chemicals or physical apparatus. Sodium chloride possesses the same chemical properties whether it be one hundred feet below the surface of the earth and mixed with various other salts, or whether it be in a bottle labelled chemically pure. It may be that living organisms are nothing but physico-chemical-colloidal complexes, but life does not consist of salts and physical conditions. Life is a mobile, dynamic force, which, according to our present knowledge of the structure of protoplasm, carries on its activities within a physico-chemical matrix. Life is a type of energy that has so far never been isolated or measured as we measure the energy of heat, light, mechanics, electricity, etc., The biologist has called this energy of life, biotic energy, and is devoting his time to its understanding.

One of the chief characteristics of life is its sensitiveness to change, whether external or internal. It is a familiar fact that protoplasm consists largely of water, the percentage varying from about eighty-five to ninety-five per cent. The organism then in reality is a solution which, so long as life is present, is in a state of equilibrium with its environment. While, as solutions go, the living organism is fairly stable, we know that on the whole it does not require a great change in the surrounding conditions to so disturb the equilibrium that death will result. For aquatic animals and plants, slight alterations in the chemical reaction of the water in which they are living will quickly result in their death if they are unable to escape from the detri-

mental conditions. It cannot be expected that plants and animals that have been collected at some remote point and shipped to a distance will retain much of their normal behavior activities, and in many cases their physiological make-up will be decidedly altered. And this is not all; even though the organisms might be secured in a fairly normal condition, one learns little of their real nature in the laboratory. True, the students may form a clear conception of phylogenetic series as such, but they will derive no real understanding of the forces of evolution from their laboratory work. They may become familiar with the mechanics and anatomy of the organisms, but will have little appreciation of the life which makes use of the structures which they have studied.

In the beginning, I grouped the biology instructor's problems under two heads; those dealing with the organization of the course, and those concerned with the securing of the material. There is a decided tendency upon the part of most teachers to leave the organization of their subject to the writers of textbooks. The value of textbooks requires no emphasis, but it should be the task of every teacher to modify the textbook to meet his own needs. At the present time we have many textbooks in elementary biology, but the fact that others are constantly appearing shows that there is as yet no agreement as to the subject matter that should be incorporated in the ideal biology textbook.

The securing of the proper material at the proper time is, however, usually the most serious problem which confronts the enthusiastic teacher who wishes to conduct a real, successful, live course in biology. Difficulty and delay in securing material may play havoc with the most carefully planned course, and there is no biology teacher who has not experienced such difficulties and delays to a greater or less extent. Furthermore, I am sure there is no teacher of the biological sciences who will not gladly listen to any suggestion which may tend to lessen this handicap.

The suggestions which are contained in the following pages are not put forward as a panacea for the troubles of the biological teacher, but I am convinced that they will bear consideration. Let me say at once that I believe that a training in the science of ecology will remove many of the most serious difficulties relating to the conducting of high school biology courses. In this connection, I wish first to outline the advantages which may be confidently expected to accrue as the result of the introduction of ecological methods into high school biology.

1. The teacher will become thoroughly acquainted with the region in which he is teaching, and will learn where and when to collect his own materials.
2. Ecological methods make it not only easy but essential that the plants and animals be studied together. A course in general biology will automatically result.
3. Ecological methods of analysis necessitate investigations into the texture, composition, etc., of soils. The practical questions relating to agricultural botany and zoology will thus receive attention.
4. The student of ecology must know the animals and plants with which he is working, and the questions of their taxonomy and morphology must be considered.

Ecology has been defined as that branch of physiology which has to do with the relation of the organism to its environment. Ecology is differentiated from the type of physiology with which we are most familiar by the fact that it deals with the organism as a whole and takes little or no account of the physiology of organs. The ecologist is interested in the reactions of the whole organism and is not primarily concerned with the functioning of its liver or the composition of its digestive fluids. In a more general way ecology may be defined as the science of natural history. We do not need to go far back in the history of biology to reach the time, when all biologists were students of natural history. Agassiz, Lubbock, Romanes, Faber, Wallace, Darwin, all were students of nature and did little work in the laboratory. They spent their time studying nature in the field, and we are all familiar with the fact that Darwin and Wallace collected the enormous mass of material upon which they based their individual conceptions of the evolutionary hypothesis, during their excursions into many parts of the world.

With the introduction of the evolutionary idea, backed by so much data, biologists everywhere began a frantic search for more evidence on the subject. It soon became apparent that one of the most fruitful sources of study was to be found in the structure of animals and plants, and as a result, biologists have for the last sixty years devoted a very large proportion of their time to the study of animal and plant anatomy or morphology. A secondary result, of this accumulation of facts concerning the structure of organisms has been, that we have taught in our schools the things which we know best and the high school and college curricula of today reflect this fact in the emphasis laid upon the study of morphology. The botany teacher starts with the blue-green algae and works up through the Protococcales, Volvocales, etc., etc. The student may learn of minute structures to be found in *Pleurococcus* which has been secured from a supply house, and will not hear of the acres of

this alga that are growing on the trees, fences, stone walls, etc., all about the school building. The zoology teacher will answer every question concerning the complicated nuclear changes during the conjugation of *Paramoecium* without being able to tell the student where the animal is to be found in nature, or what it does under the varying natural conditions. I do not mean to intimate for an instant that I have struck upon the weak points in the experience of all biological teachers, nor do I mean to condemn any teacher for his weaknesses, whatever they may be. They are teaching what they were taught, and the fault lies with the science of biology and not with the teachers.

However, biology is awakening from this lethargy of extreme specialization; we are beginning to realize that the study of structure was nothing but a stage in which we have already lingered too long. We remember that the man who revolutionized the science of biology in 1859 and set the world by its ears, with a nightmare of being a product of evolution rather than of special creation, was not a product of a man-made laboratory, but was a scientist who secured his information at first hand from the laboratory of nature herself. With this in mind, biologists are no longer going afield, as collectors alone, but as students anxious to learn, at first hand, the working methods of nature's own laboratory.

For many years ecologists were troubled and pestered with the statement that natural history was not and could never be a science. According to these critics, nature was such a complex hodgepodge of unknowns that it could never be organized into a science. While this is without doubt more or less true, those who made such statements failed to remember that the evolutionary theory found its origin in this same hodgepodge, and that every science which we know has originated from the same source. The universe in which we live contains more uncovered sciences than man has ever dreamed of. New sciences are arising on every hand. Bacteriology is less than fifty, and protozoology less than twenty-five years old, not to mention the numerous minor "ologies" that are arising on every hand. The founding of a new science requires merely, the accumulation of a sufficient number of related facts, and we have not even gotten below the surface of the tremendous body of facts that is presented to us in nature.

Ecology is the result of an accumulation of facts that show beyond a doubt, a definite relation between the distribution

and physiology of organisms; in other words, animals and plants select the environments in which they live. The complexity of the relationships involved are bound to be great, which fact but adds to the interest attaching to the science.

All sciences, and especially the laboratory sciences, are readily divisible into descriptive and experimental aspects. In ecology we may make observations and collections which show us that certain animals are characteristic of sandy areas, and others of woods. One species of fish lives in the ripples, and another in the pools of the stream. One insect lives on the ground under the leaves, and another high up in the trees. This analysis may be carried out in great detail and illustrates what is being done in the way of descriptive animal ecology. The descriptive scientist need not necessarily trouble himself with explanations of the facts which he describes, but the experimental worker must determine the why of every fact. Why do certain species of insects live only in sandy regions, and other species in mesophytic woods? Why does one tiger beetle lay its eggs only in clay, and another only in a humus soil? The whys which the experimental ecologist is trying to answer furnish a never-ending list of problems which can be attacked only from the experimental side.

The bearing of all that has gone before upon the teaching of biology in the high school seems to me to be quite clear. Taking it for granted, for there can be no denying the fact, that the place to study nature is in the field, what is there that the high school teacher can do to interest and instruct the student? Let me mention very briefly some of the specific things that may be done. From the descriptive side one of the most interesting phenomena worked out by ecologists is the fact that natural conditions are seldom, if ever, stable. The physiographer finds his science founded upon the fact that the forces of erosion are constantly changing the topography of the earth's surface. The plant ecologist finds that these changes in topography are accompanied by changes in the vegetation of the area, and the animal ecologist finds in turn, that the topographic and vegetational changes are closely followed by changes in the species of animals which inhabit the region. We have then a succession of topographic conditions with an accompanying succession of plant and animal forms. This we call ecological succession. Ecological succession may result from other changes in environment than those related to topography, but the interesting fact at

this time is that these changes are easily recognized and understood by the high school student. Naturally, we cannot wait for a single area to pass through the different stages, but we can readily find the different stages, represented in different parts of any given region.

There are several other types of succession that are also easily studied. When we think of it, we realize that there must be a change in the types of animals and plants that are active at the different seasons of the year. This seasonal succession study works out exceedingly well if begun in the fall, and can be carried through the winter in a study of hibernation, and taken up again in the spring with the beginning of activity of organisms.

There are also daily successions or rhythms that are easily observed in the field.

Another type of descriptive field work that is always of great interest is the observation of the detailed behavior of a single form for a given time. Thus one may select a certain insect and describe its every movement for ten minutes. This is an exercise that appeals to the students more, and more each time it is done, as their powers of observation become sharpened.

One can make various analyses in the field. The temperatures of the different soils, the difference between air and soil temperature, the differences in temperature in different parts and depths of ponds, etc., are readily obtained by the students. Other simple analyses of environmental conditions, such as the measuring of the light intensity inside and outside a dense wood, and the determining of the rate of evaporation, are operations that require neither complicated nor expensive apparatus, and when these analyses are correlated with the actual distribution of the plants and animals as determined at the same time, they furnish a type of work that has been found to appeal to the high school students in places where it has been tried. For the laboratory there are many experiments which may be performed with inexpensive apparatus, but I cannot go into detail as to these at this time.

I do not wish to leave the impression that I am advocating the crowding out of biology as it is now taught in the high schools, in favor of a course in ecology. The point I wish to make and to emphasize strongly, is that the introduction of ecological methods into the teaching of high school biology, will make the instructor more independent of the textbook and of the supply

house than he is at present, and at the same time will make it possible for him to put new life into the subject as he comes into closer contact with nature, the giver of all life.

On the other hand, I am not unaware of the difficulties which the above suggestions will entail. Field trips do not always fit well into the regular high school schedule, yet they are absolutely essential to the study of ecology. Classes in high school biology are frequently large and would probably become larger with the introduction of field trips, while a large class in the field soon becomes unmanageable. These and other objections occur at once. However, I believe that most of the objections can be removed by a proper adjustment of schedules and limiting of the numbers allowed to take the course. Of one thing I am certain; with every school situated within working distance of the great laboratory, which nature has already prepared for us, a laboratory that we could never duplicate indoors, however liberal the appropriation, it is not proper that we should continue to limit our biological instruction to the preserved specimen and the dissecting pan. There are many instructors who are already well on the way toward the transfer of the study of biology from the laboratory to the field, and I believe that within the near future this will be the procedure followed by all enthusiastic teachers. With this return to the study of the real, living environment which surrounds us, we must soon develop a type of observer who will see in nature, not a hodgepodge, but a living, dynamic complex of factors that but awaits analysis, and we can rest assured, I believe, that only from such observers will there arise a new Aristotle or a new Darwin to clear away our ever-increasing impedimenta of miscellaneous biological facts, and set us once more on the straight road to a true understanding of life.

LIBERTY LOAN ACTIVITIES.

A conference was held in Washington during the week beginning December 10, which lasted several days, between Secretary McAdoo and other Treasury officials and representatives from Liberty Loan organizations all over the country, which included officials of the Federal Reserve Banks.

Plans for future Liberty Loan campaigns were perfected and an organization at once wider and closer was arranged for. Rural communities and small towns and small cities particularly will feel the effect of the new campaign plans.

THE APPLICATION OF GENETICS TO BREEDING PROBLEMS.

By Leon J. Cole,

University of Wisconsin, Madison.

Great advances in science have usually followed the development of some new *method* of research. This is strikingly true of genetics. Before the present century the subject of heredity presented a field characterized by indefiniteness—roads were absent or ill-defined, while guideposts pointed this way and that, and seemed to lead to no definite destination. Genetics, perhaps of all sciences, seemed farthest from a possible inclusion among those which are classified as "exact." To be "exact," a subject must have definite units which can be recognized and defined, which exhibit a high degree of constancy, and which consequently can be dealt with statistically—that is, mathematically.

To be sure, unknown to the scientific world at large, the foundations for just such an "exact" treatment of the phenomena of heredity had been laid by Mendel many years before—but Mendel was before his time. It is still less than two decades since his work came to be appreciated, but in that time "Mendel's Law" has been firmly established in the history of science as a real law of nature, expressing a great generality of far broader application than was first dreamed. We no longer hear the question asked, "Do you believe in Mendelism?" any more than, "Do you believe in evolution?" The questions today are as to the details of its application.

Mendel's first and perhaps greatest service was to supply the science of genetics with a *unit* with which to work, albeit a somewhat imperfect and superficial one, and one which has now been largely discarded in favor of another less tangible, in that it cannot be observed directly, but more stable. Mendel's experiments demonstrated the advantage of focussing attention upon single observable qualities, and supplied us with the concept of the *unit character*. He demonstrated seven pairs of alternative unit characters in the garden pea, and showed that they are all inherited in the same fashion. Since 1900 extensive investigations have disclosed in both animals and plants hundreds of characters which follow the same law.

It soon became apparent, however, that there were perhaps even more characters which appeared to be units, but which were not inherited as such. While they were truly unit *characters*, they were nevertheless complex in their inheritance.

This led to the realization that strictly speaking the characters are not inherited at all; what is really inherited is a *determiner* for the character—something which determines that such a character will develop. The character is only the expression in the development of the individual of the presence of the determiner which causes it. If in its heritage from its parents an individual receives a determiner for a character, the character may develop; without the determiner it cannot. The *determiner*, also commonly called *gene* or *factor*, is then a hypothetical something responsible for a character, but a thing which cannot be studied directly. The factors are units which can be studied only through their manifestation in the characters. Such a study reveals that many characters are complex because they

Fig. 1. Difference in growth habit in soy beans. These pictures were taken on the same day. The type represented by the small plant on the left averages about 8 inches shorter and matures nearly a month earlier than that on the right. The difference is due to a single hereditary unit.

depend not upon a single factor, but upon the joint action of several factors. Some of the things which can be studied about factors are: (1) their effect (the characters they produce); (2) their inheritance; (3) their relation to one another (supplementary, complementary, linkage); (4) their location (relation to visible structures in the cell); (5) their constancy; (6) their origin.

Scientific breeding must consist of (1) an *analysis of the hereditary factors* or genes involved, and (2) *manipulation* of these in breeding to produce the combinations which will give the desired results *as expressed in characters*; for the ultimate concern of the practical breeder is, it must be remembered, characters and not genes. Considerable advance has been made in this direction, but in the main scientific breeding is still in the experimental stage. In what follows certain breed-

ing problems will be discussed from the standpoint of their possible explanation on the factor basis. The illustrations are from the investigations of the Department of Experimental Breeding of the University of Wisconsin.

Selection on the Basis of Factors.

Selection is the process by which all progress must be made in breeding. In practice selection is made on the basis of characters, and notable success has been attained in this way as is attested by the great variety and excellence of plant and animal forms adapted to man's uses. Selection by this method is,

Fig. 2. Albino female guinea-pig (at the right), pink-eyed white male (next to it), and their three offspring, which are pigmented and have dark eyes.

however, a long process and is indirect and uncertain. When selection can be made on the basis of factors it may be direct and certain. The simple condition of this is illustrated by the attempt to produce a true-breeding strain with respect to any dominant Mendelian character, such, for instance, as the difference in growth habit in soy beans shown in Figure 1. One of these is much taller than the other, more spreading in habit, and decidedly later in maturing. This is a simple Mendelian dominant to the shorter, early maturing type—that is, a single factor is responsible for the difference. In this case a single *unit factor* corresponds to a definite *unit character*. Nevertheless, by ordinary selection methods alone, the process of obtaining a true-breeding strain of the tall type might prove to be a long one; a knowledge of the factor relation, however, permits of its easy accomplishment in a single season.

Perhaps a better example of the way in which a knowledge of the heritable factors may lead to a desired result is that of what we have termed our synthetic pink-eyed white guinea pigs. The albino guinea pig, white with pink eyes, is a well-known fancy variety, but it practically always has smutty

extremities, that is, more or less dark pigment on nose, ears, and feet. It occurred to Dr. Ibsen that a guinea pig meeting all the requirements of a pure white animal with pink eyes might be made up in an entirely different way, by combining the factors for "pink-eyed," "non-yellow," and 'non-extension of dark pigment." This he proceeded to do, and in two or three generations had what he sought—a guinea pig that was not an albino, but is a better albino in appearance than a true albino! Furthermore, this new variety breeds true to type when bred to its kind, but that it is not an albino is indicated by the fact

PER CENT FERTILE EGGS HATCHED

	1913	1914	1915	1916	1917
Inbred pullets	67	49	41	18	0
Checks	67	81	56	64	47

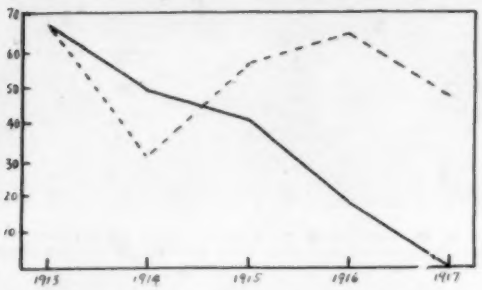


Fig. 3. Table and chart showing the effect on hatchability of eggs of five years of inbreeding of Rhode Island Red fowls. Solid line, inbred pullets; broken line, checks.

that it produces dark-eyed pigmented offspring when bred to an albino (Figure 2).

Inbreeding.

The experiences of different breeders resulting from the practice of inbreeding, or the mating together of closely related individuals, have been very diverse and contradictory, and have seemed to defy explanation. There was a general consensus of opinion that inbreeding tended to "intensify" characters, but it seemed to work impartially on good characters and bad, and there was no telling which would be affected. Furthermore, it was thought that inbreeding lowered vitality, though some failed to get this result. Doubtless many variables are concerned, and in order to eliminate one of these an experiment was planned with Rhode Island Red fowls in which selection was based strictly on a character which supposedly has no vital value, namely, color. One of the most striking results is shown in the table and chart in Figure 3. Hatchability of the eggs

seemed to be principally affected, so much so in fact that in a period of five years of matings of brother to sister, the hatching power of the eggs steadily declined from sixty-seven per cent to zero, which naturally brought a definite termination to this phase of the experiment.

This result is purely empirical. What is the explanation? Is it not possible that if a different system of selection had been adopted the result would have been different? This seems probable, and is now being tested. In the meantime a

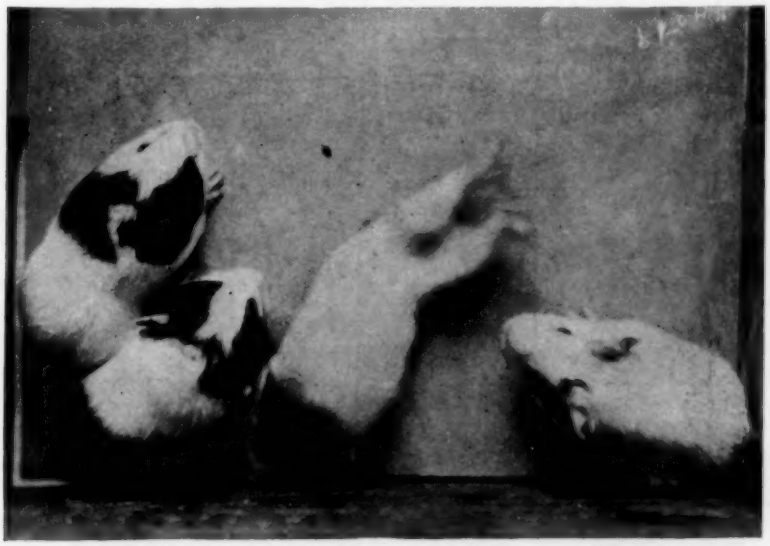


Fig. 4. Litter of four guinea-pigs from parents both of which carried a defective trait in their germ plasm. Three of the offspring are normal, while one is defective. The trembling of the legs is indicated by the blurring of the image.

plausible explanation is at hand on a factor basis. It is first necessary to recall that all the heritable factors an individual can receive must come directly from one or other of its parents, and indirectly from ancestors more remote. As the number of the possible ancestors is limited, the possible diversity of factors is likewise limited. With close inbreeding, such as mating of brother to sister, it is therefore impossible for any new factors to be introduced into the germ plasm, while on account of Mendelian segregation it is more than probable that factors will be lost out, especially any whose presence cannot be readily inferred from obvious characters. Some of these may be of vital importance and their loss will result in a defective or weakened progeny.

Experiments with fruit flies have shown that there are certain

factors—units which behave in simple Mendelian fashion—whose presence is absolutely essential to the life of an individual. Their absence produces a lethal effect—in other words, kills the fly. There are doubtless other physiological factors of this sort with varying degrees of importance. Thus we have found a case in guinea pigs where the absence of a particular factor is

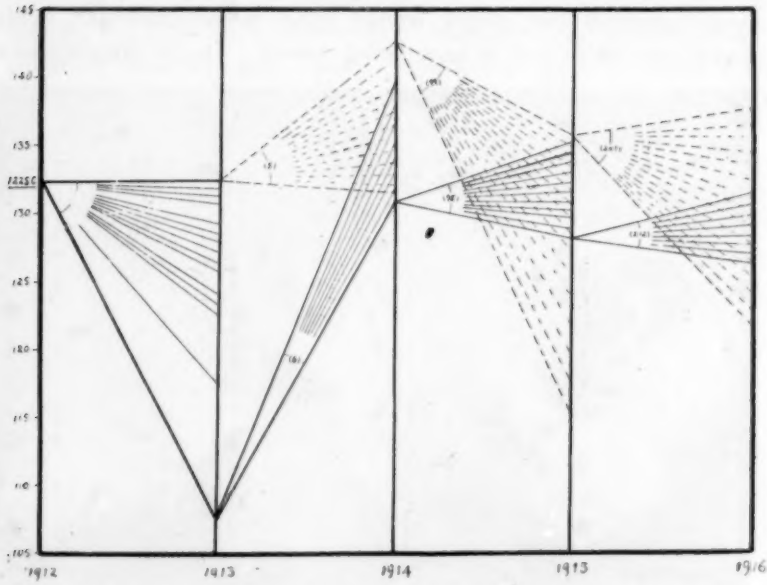


Fig. 5. Pure-line selection in soy beans. Four years of selection with respect to iodine number of the oil were ineffective in producing high and low strains. Broken lines, progenies from the high selective line; solid lines, progenies from the low selective line.

always lethal, but apparently only because such animals always starve to death after they are born. When born, they are as large and strong as any of their litter mates, except for a sort of palsy which prevents their getting about and feeding. Figure 4 shows a litter of four guinea pigs, three of which are normal, while one shows this defect. This case has a strong resemblance to the inheritance of feeble-mindedness and some forms of epilepsy in man.

Pure-Line Breeding.

In certain plants which are naturally self-pollinating, inbreeding is the rule, and good types once established suffer no further deterioration. This makes it very easy for the breeder to isolate and fix desirable types by methods now regularly in use, particularly in the improvement of the cereal grains. On the other hand, since nothing new can be brought in, improvement of a

pure line by selection alone, that is, without out-crossing, is precluded. This is illustrated in a study of the effects of selection with respect to the chemical character of the oil of a pure-line strain of soy beans (Figure 5). Selections respectively from the highest and from the lowest plants with respect to the degree of saturation of the oil, carried on for a period of four years, have produced no hereditary effect—the progeny of both lines of selection continue to vary over the same range.

THE SEARCH FOR FACTORS.

By far the greater number of characters of economic importance are of the complex sort, dependent upon several to many

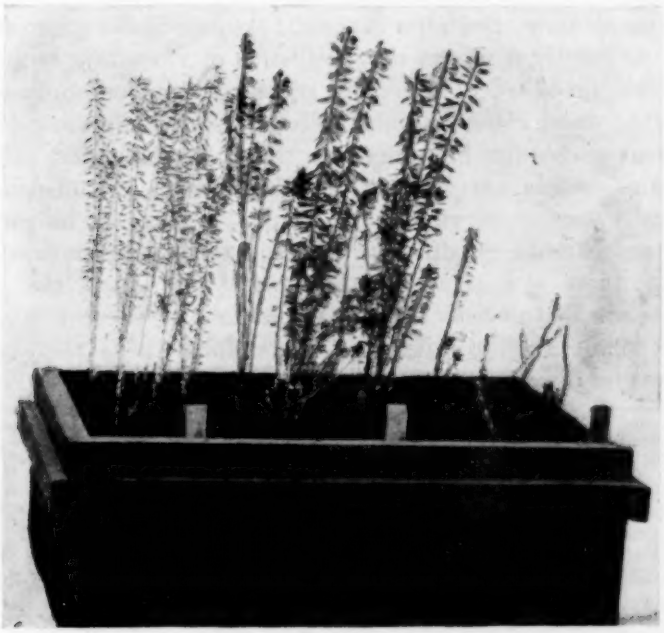


FIGURE 6.

factors. The big task is to analyze such characters—to identify the factors and learn how they are inherited. Such indefinite characters as milk and meat production offer especial difficulties but a beginning is being made even with these. Jersey cattle, representing the most refined dairy type, and Polled Aberdeen Angus, a specialized beef type, were crossed, not with the idea of producing a new breed, nor in fact with any immediate practical object in view, but in order to learn what characters are independent and what go together; what ones, if any, be-

have in simple Mendelian fashion and what ones are complex—in short, to make just such an analysis as has been suggested.

One other example may serve to show the nature of these investigations. Last year Professor L. R. Jones read before this society a paper in which he described his successful attempts to breed a strain of cabbage resistant to the disease known as "yellows."[1] His experiments demonstrated clearly that there is a distinct heritable difference between the resistant and the non-resistant strains. We are now engaged in studying the method of inheritance of this difference. While the experiments have not yet gone far, they seem to show clearly that *resistance* in this case is not a simple character, but depends upon several, perhaps many, heritable genes. A knowledge of these factors would greatly facilitate the production of a resistant strain that would "breed true." Flax wilt is caused by an organism similar to that which causes cabbage yellows, and flax offers much better opportunities for investigation. If susceptible and resistant strains of flax are crossed, the first generation offspring are usually even more vigorous and fully as resistant as their resistant parents. (Figure 6). In the second generation, however, there is a great variability, and here again the indications are that at least several factors must be present to make a flax plant able to withstand successfully the attacks of the parasitic fungus which causes the wilt.

[1] Jones, L. R. "Some Recent Advances in Plant Pathology," SCHOOL SCIENCE AND MATHEMATICS, Vol. 17, No. 2, February, 1917, pp. 95–100.

WHY YOU MUST BUY LIBERTY BONDS.

War is a glutton that lives on lives and riches. There is no limit to the devouring greed of war. As long as there is an unconquered life, or an undevoured dollar, war is hungry.

When war attacks a nation there is no choice—every able-bodied man knows that he must fight—now or later. Selective drafts may miss a man here and there for a few months, but if the war goes on, a time comes when every man who can walk and carry a gun must go to the colors and fight for the very life of his country, his family, himself.

Remember these things. The nation has a right to take absolutely every dollar of property in the United States for the life and death war against tyranny, autocracy, slavery, and foreign aggression and vassalage. But the nation does not intend to exercise that final and desperate right. No! The Government says: "The nation is fighting for its life. Lend us your money. We will give you Liberty Bonds, secured by all the wealth and sovereign taxing power, bearing 4 1-4 per cent interest, and protected by a good sinking fund, with tax exemptions to make the loan better. Avoid the extreme necessity. INVEST IN ALL THE LIBERTY BONDS YOU CAN."

IS HIGH SCHOOL SCIENCE ON THE DECLINE?

Editor, SCHOOL SCIENCE AND MATHEMATICS:

In the March number of your journal, page 249, I made the ollowing statement: "A study of the reports of the Commissioner of Education for the past twenty years, incomplete though those reports are, leads to the conclu ion hat the total percentage enrollment in high sch ol science subjects did decline from about 1890 to 910, bu from 1910 to 1915 there was a slight increase." This tatement has been challenged by a scientist who e word carries much weight. I should like a little space in which to present the facts upon which i base my conclusion.

On page 487, Volume II, *Repor of the Commissioner of Education for 1916*, under the heading, "Student in Certain Studies in Public High Schools Since 1890," we find the following dat :

PER CENT OF TOTAL ENROLLMENT.

	1890	1895	1900	1905	1 10	1915
Astronomy		4.79	2.78	1.22	.53	.28
Physics	22.21	22.77	19.04	15.66	14.61	14.23
Chemistry	10.10	9.15	7.72	6.76	6.89	7.38
Physical geography		23.89	23.37	21.52	19.34	14.58
Zoology					8.02	3.21
Botany					16.83	9.14
General biology						6.90
Geology		5.00	3.61	2.34	1.16	.48
Physiology		29.95	27.42	21.96	15.32	9.48
Dom stic economy					3.78	12.89
Agricu tu e					4.66	7.17
Totals	32.31	95.55	83.94	69.46	91.14	85.74

In considering these data we should keep the following points in mind:

1. stronomy and geology were more generally tudied in 1890 than at any later date.

2. Physical g ography, botany, oology, and physiology were also well recognized high school subjects in 1890.

3. That many scienti ts hesitate to include all of the teaching of agriculture and domestic economy as science instruction.

4. That general science has never been listed by the Commissioner in his reports.

5. Finally, we should also remember that the fourteen-weeks courses of 1890 and 1895 have generally given place to eighteen-weeks courses or one-year courses in 1915. Until we have some more reliable source of information, I think we shall do well to draw our conclusions from these figures from the Commissioner's reports regarding percentage enrollment in high school subjects.

FRED D. BARBER.

CONCRETE HAS MANY USES.

Concrete, because of its great resistance to fire and to the shock of explosions, is adaptable to a wide variety of uses, according to the United States Geological Survey Department of the Interior. It is cheap, easily and quickly handled, sanitary, and durable, and its characteristics render it of great military importance. Among the military uses to which concrete is put are the construction of armories, barracks, roads, bridges, coast and interior fortifications, gun emplacements, trench linings, bomb-proof shelters, magazines for explosives, tunnels, retaining walls, sea walls, wharves, dry docks, water reservoirs, aqueducts, sewers, sewage-treatment works, incinerators, stables, floors, roofs, munition-factory buildings, warehouses, fuel-oil tanks, barges, and even in the interior of battleships.

HOW MISSISSIPPI GOT HER HILLS.

Is Mississippi a plain or a plateau, swampy, undulating, hilly, rugged, or what? How many people know? Precise determinations of altitude made by the Government show that its average height above sea level is several hundred feet, or relatively high for a state bordering the Atlantic or Gulf coast, and its valleys are surprisingly deep.

But the most striking features of the surface of the state are the gullies —little valleys carved in bright-colored sands and clays with sides so steep and upper ends so abrupt that they prevent you from going across country anywhere you like even afoot, and although actually only fifty to two hundred or three hundred feet deep, they seem to be good-sized canyons. If you enter one of the canyons at the lower end or find a place where you can climb down a gully wall, you are hidden from the world and may soon get delightfully lost. You may wander about between walls striped horizontally with red, brown, and cream, a new choice of routes continually presenting itself in the intricate ramifications—the whole like a labyrinth; but just as a tributary stream joins its main only at the lower end, there is, as a rule, only one place where any single gully or passage is connected with another.

Even in the southern end of the state, hills reaching over five hundred feet above sea level, or two hundred or three hundred feet above their bases, and some of the uplands are slashed in every direction by innumerable gullies, laying bare the substrata of varicolored irregular layers of sand, clay, and in places gravel.

Nevertheless there is an immense area of arable and fertile land in Mississippi. The soil is so light that with the considerable slope of the hillsides care must be taken to prevent washing and the growth of gullies, which, though disastrous to farming where neglect allows them a start, make charming scenery and afford the geologist a fine opportunity to decipher the complex and in many ways peculiar history of the state.

A short scientific paper dealing with the character of materials exposed in the gullies and a part of the geologic history of the state has recently been published by the U. S. Geological Survey, Department of the Interior.—[*U. S. Geological Survey Press Bulletin.*

HEAVING OF PAVEMENTS BY FROST.

It has long been known by highway engineers that pavements laid on clay soils are more apt to be heaved by frost than those laid on sand or gravel. This has hitherto been attributed to the fact that less water exists in sand or gravel than in clay directly beneath a pavement. Prof. Stephen Taber, professor of geology of the University of South Carolina, has conducted experiments that undoubtedly upset this old theory.

In a paper on "Pressure Phenomena Accompanying the Growth of Crystals," presented before the National Academy of Science last year, Prof. Taber gives an account of what happens when moist clay beneath a stone freezes. The stone cools more rapidly than the clay, so that ice crystals first form at the points of contact between the stone and the clay. The water in the interstices of the clay itself does not freeze so rapidly as water on the surface of the clay, for the freezing point of water in capillary spaces is considerably below that of water in the open. But the freezing of the thin skin of water on the surface of the clay results in more water being fed up from below, very much as a lamp wick feeds up more oil as fast as the oil at the top burns. Then another thin layer of ice forms on the surface of the clay beneath the first layer of ice, and so on, steadily raising the stone by the building up of a layer of ice between the clay and the stone.

In sand or gravel the same phenomenon does not take place, even when saturated with water. Once the water in the pores of the sand begins to freeze, it freezes progressively downward, because the pores are not so small as to form capillary spaces, and do not, therefore, lower the freezing point of the water.

Experiments were made by Prof. Taber by which the existence of a layer of ice between moist clay and a weight was proved, coincidently with the absence of an ice layer between wet sand and a weight. Hence his theory is established beyond doubt. It also accounts completely for such phenomena as the lifting of blocks of concrete weighing many tons a distance of several inches even when the frost had penetrated the clay soil to a depth of only a few inches.

Highway engineers will not be slow to see the uses to which this new bit of scientific knowledge can be put.—[*Engineering and Construction.*

STENOGRAPHERS AND TYPEWRITERS WANTED—MEN AND WOMEN.

The United States Government is in urgent need of thousands of typewriter operators and stenographers and typewriters. All who pass examinations for the departments and offices at Washington, D. C., are assured of certification for appointment. It is the manifest duty of citizens with this special knowledge to use it at this time where it will be of most value to the Government. Women especially are urged to undertake this office work. Those who have not the required training are encouraged to undergo instruction at once.

Examinations for the Departmental Service, for both men and women, are held every Tuesday, in 450 of the principal cities of the United States, and applications may be filed with the Commission at Washington, D. C., at any time.

The entrance salary ranges from $1,000 to $1,200 a year. Advancement of capable employees to higher salaries is reasonably rapid.

Applicants must have reached their eighteenth birthday on the date of the examination.

For full information in regard to the scope and character of the examination and for application blanks address the U. S. Civil Service Commission, Washington, D. C., or the Secretary of the U. S. Civil Service Board of Examiners at Boston, Mass.; New York, N. Y.; Philadelphia, Pa.; Atlanta, Ga.; Cincinnati, Ohio; Chicago, Ill.; St. Paul, Minn.; St. Louis, Mo.; New Orleans, La.; Seattle, Wash.; San Francisco, Cal; Honolulu, Hawaii; or San Juan, Porto Rico.

TO THE CITIZENS OF AMERICA.

One million, eight hundred thousand of America's brave sons are now serving in the Army and Navy of the United States. Thousand of them are already upon the battle fields of France, fighting and dying to save the liberties and rights of those who stay at home and to secure democracy and freedom against Prussian brutality and military despotism. Their blood already consecrates the soil of noble France.

Who can think of their heroic sacrifices without emotion?

Who can contemplate their trials and sufferings, their dangers and struggles, without setting ablaze the fires of patriotism in his soul?

Who can look upon the blue jacket of the sailor or the khaki jacket of the soldier without admiration for the indomitable hearts that beat beneath—hearts that may soon be stilled in death as the price they pay to save civilization?

We must support our gallant sailors and soldiers. We must make them swift victors in their fight with the Kaiser. We can do it if we at home do our duty with the same quality of patriotism that animates our men in the trenches. The least duty we can perform—and we should be eager and happy to perform it—is to lend our money, every available dollar we have or can save, to our Government in order that our gallant sons may be supplied with all they need to save America.

No true patriot will fail to buy United States Liberty Bonds of the Third Liberty Loan.

TWO KINDS OF PATRIOTISM.

Mr. Farmer, you have brought a lot of idle land into tillage this spring. You are going to raise all the grain, and forage, and live stock your farm can be made to produce. That's one kind of patriotism and a very necessary kind.

Every farmer who brings an acre of land into cultivation is a soldier on the firing line for liberty and democracy.

But there is another kind of patriotism that is just as necessary. It is just as necessary that the stuff you produce shall be put at the disposal of the fighting forces, as it is that you should raise it.

That means money. You have to have money to pay for the labor of farming your land and producing grain and stock. The Government must have money to buy your produce for the fighting men in France. Money is absolutely necessary to buy food, munitions, clothing, ships, and medical stores.

You are doing your duty in raising the crops, that is very true. But in a war like this one, no man does his full duty who does not do all that he possibly can.

Bring out the grain you have stored away. Sell it at a fair price fixed by the Government.

Bring out the money you have stored up in the banks, or hidden away in your iron box behind the barn. Every dollar is urgently needed.

Invest every idle dollar in Liberty Bonds. The Government will repay you in a few years. Meantime you will receive interest at the rate of 4 1-4 per cent, with valuable tax exemptions to make the investment better. INVEST EVERY DOLLAR YOU CAN IN LIBERTY BONDS.

Every dollar you bring out of concealment means ten dollars added to the fighting capacity of the United States in the world war.

UNIVERSITY OF MICHIGAN SUMMER SCHOOL IN BIOLOGY.

Teachers of the biological sciences in secondary schools and colleges will be glad to know that the University of Michigan offers excellent training by means of field and laboratory work in the ecological, taxonomic, and natural history aspects of zoology and botany during the summer at its Biological Station, located on Douglas Lake, near Pellston, in the northern part of the southern peninsula of Michigan. The station is in the famous summer resort region, being about equidistant from Petoskey, Mackinaw City, and Cheboygan,. Possessing all the climatic advantages of this region, it is sufficiently isolated to be free from the disturbing features of a summer resort and the summer resort crowd. Teachers can recuperate from a hard year's work and yet gain six to eight hours' credit toward a baccalaureate or an advanced degree.

The courses in zoology deal with the natural history of insects, birds, and other vertebrate animals, and the ecology of invertebrates, while special and research work is offered along lines suggested by these courses. In botany, courses deal with the classification of flowing plants, plant

ecology, and plant anatomy. Research work is offered along ecological, anatomical, and systematic lines. Opportunity for investigation is offered to a limited number of investigators from other institutions upon payment of a small fee.

A teaching staff of well-trained and experienced men has been chosen from the faculties of the University of Michigan, University of Colorado, Kansas State Agricultural College, and Carthage College. The session begins on July 1 and ends on August 23.

Those desiring further information in regard to courses, credits, and living conditions may address George R. La Rue, Director of the Biological Station, University of Michigan, Ann Arbor, Mich.

CLASS ROOM SAYINGS.

"Water cannot be cooled above the boiling point because the boiling point of water and the condensing temperature of steam are the same, so the water would condense in steam."

"Take a *magnate* and find out with a compass which end is north and which is south. Then rub the south end of the magnate on the end of the bar marked plus."

SEATTLE, THE FOURTH PORT OF THE UNITED STATES.

During 1917, Seattle passed San Francisco in the value of her foreign trade, which amounted to $600,000,000, thereby taking rank as the fourth port of the United States. This marked advance is due, of course, to the present abnormal conditions. War has revolutionized shipping routes. Supplies for the Russian armies constituted a large part of Seattle's exports. But her admirable geographical situation fits Seattle to maintain the position she has reached. Located at the most advantageous point in an extensive network of waterways, with sufficient depth of harbor and convenient dockage, within easy reach of a productive district, a position of local prominence was early assured her. Lumber and fish constituted the first important trade. Forest products were in demand along the entire west coast of North and South America. The cities on the treeless Peruvian and Chilean coasts and even far interior towns of the Andes called for the pine of Washington's forests. Railroads, when they came, made the entire Northwest a hinterland for Seattle, while no point was so well situated as a gateway to the gold and fur-bearing regions of Alaska. When commerce with the Far East was opened up, Seattle was ready to offer the shortest route by which wheat and manufactured articles from the northern United States could be exchanged for the products of the Orient (see W. M. Gregory: "The Growth of the Cities of Washington," *Journ. of Geogr.*, May, 1916). The heavy war shipments to Asiatic Russia have now made her America's foremost Pacific port.—[*Geographical Review.*

PATRIOTIC TEACHERS.

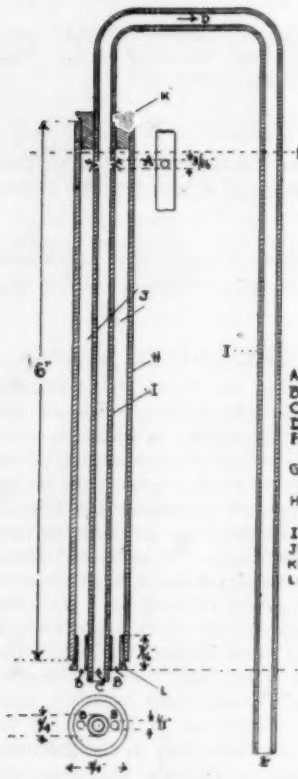
There is no more loyal and patriotic class of people in the United States than its Science and Mathematics Teachers. They are showing their loyalty not only in the purchase of Third Liberty Loan Bonds themselves, but in showing to their pupils how necessary it is that they should invest their savings in this most important enterprise, at the same time urging their parents to purchase their Bonds until the pinch is actually felt. Teachers, push this sale to the utmost!

LABORATORY METHOD OF MAKING A SELF-STARTING SIPHON.

By Waller Bonner,

High School, Montclair, N. J.

This siphon is constructed as shown in the drawing. It consists of a long bent tube I, which runs through the center of a glass cylinder H, to which it is attached by rubber stoppers K and L.



Two holes are made in the tube I and are lettered A-A in the drawing. Two other holes made through the lower rubber stopper are marked B-B.

In operation the siphon is thrust into the liquid until the water rises in tube I to the level F. Water also passes in through openings BB, compressing the air and forcing the air out through A-A into I. This air pushes the water above A-A over the bend in the tube I. When the air in the cylinder has been forced out through the opening in I the entire siphon fills with water and operates as a simple bent tube siphon.

By following this method of construction, a siphon can be made from stock materials carried in every laboratory.

MINERAL RESOURCES OF THE KANTISHNA REGION.

A preliminary report on the mineral resources of the Kantishna region, Alaska, has just been published by the United States Geological Survey as Bulletin 662-E. This paper gives a rather complete account of the mining activities of this interesting area during the last twelve years and descriptions of the many small producing placer mines and of the promising, but as yet unproductive gold, silver, and antimony prospects. It may be obtained free on application to the Director of the United States Geological Survey, Department of the Interior.

PROBLEM DEPARTMENT,

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions.*

We desire also to help those who have problems they cannot solve. *Such problems should be so indicated when sent to the Editor, and they will receive immediate attention. Remember that it takes several months for a problem to go through this department to a published solution.*

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages. In selecting problems for solution we consider* accuracy, completeness, *and* brevity *as essential.*

The Editor of this department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to the Editor. *Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

SOLUTION OF PROBLEMS.

530. *Proposed by N. P. Pandya, Sojitra, India.*

(This is repeated—no solutions received.—Ed.)

If $\sin^4\theta+\sec^2\theta+\tan^2\theta = \cos^2\theta+\csc^2\theta$, find $\sin 2\theta+\cos 2\theta$.

Solution by Nelson L. Roray, Metuchen, N. J.

$$\sin^4\theta+\sec^2\theta+\tan^2\theta = \cos^2\theta+\csc^2\theta.$$

$$\tan^2\theta+\tan^2\theta = \cos^2\theta+\cot^2\theta-\sin^4\theta$$

$$\tan^2\theta(\sin\theta+\cos^2\theta) = \frac{1-\sin^4\theta-\sin^6\theta}{\sin^2\theta}$$

$$\sin\theta\cos\theta+\cos^2\theta = \frac{\cos\theta}{\sin\theta}\left(\frac{1-\sin^4\theta-\sin^6\theta}{\tan^2\theta}\right)$$

$$\cos 2\theta+\sin 2\theta = \frac{2-2\sin^4\theta-2\sin^6\theta-\tan^4\theta}{\tan^4\theta}$$

$$= 2\cot^4\theta-2\cos^4\theta-2\sin^2\theta\cos^4\theta-1$$

$$= 2\cot^4\theta-4\cos^4\theta+2\cos^6\theta-1.$$

Algebra.

551. *Proposed by Murray J. Leventhal, New York City.*

Show that the sum of the squares of the reciprocals of the natural numbers is $1/6\pi^2$.

Remark by Nelson L. Roray, Metuchen, N. J.

This is a standard series and is proved by considering the following two expansions:

$$\tan x = x+x^3/3+2x^5/15+17x^7/315+ \cdots\cdots$$

$$\tan x = \frac{2(2^2-1)x}{\pi^2}S_2+\frac{1}{2}\cdot\frac{4(2^4-1)x^3}{\pi^4}S_4+\frac{1}{3}\cdot\frac{6(2^6-1)x^5}{\pi^6}S_6+\cdots\cdots$$

where

$S_2 = \Sigma 1/n^2 \quad S_4 = \Sigma 1/n^4$

Equating coefficients we have,

$6/\pi^2(1/1^2+1/2^2+1/3^2+ \cdots\cdots) = 1$

or

$\pi^2/6 = 1/1^2+1/2^2+1/3^2+1/4^2+ \cdots\cdots$

Also

$$\frac{1}{2} \cdot \frac{4(2^4-1)}{\pi^4} S_4 = \frac{1}{3},$$

$\therefore S_4 = \pi^4/90.$

It is evident the above expansions enable one to find the value of S_{2m}.

In *Hobb's Trigonometry* is found the solution given above.—N. L. R.

MR. F. J. MCMACKIN *sent a solution by means of calculus. We regret lack of space to publish. One incorrect solution also received.—Ed.*

Geometry.

552. *Proposed by Norman Anning, France.*

Given a regular n-gon, to construct a regular $2n$-gon having the same center and the same length of side.

I. *Solution by W. W. Gorsline, Crane Technical High School and Junior College, Chicago.*

A central angle of an n-gon $= 360/n$ and that of a $2n$-gon $= 360/2n$. Let AB be a side of a regular n-gon in a circle of center O and AC, one-half of one side. $\angle$COA will subtend a side of the regular $2n$-gon. Extend CO to circumference at D. Let EF be a side of the regular $2n$-gon in a concentric circle of center O. $\triangle$'s DOA and EFO are similar and their altitudes or apothems of the $2n$- and n-gons are in proportion to EF and AD. The apothem of the regular $2n$-gon is a 4th proportional to EF, AD, and the apothem of the n-gon and can, therefore, be constructed and then the $2n$-gon.

II. *Solution by the Proposer.*

Let AB be a side of the given regular n-gon, and O its center. On AB, on the side remote from O, construct a rectangle ABCD, having

$$BC = OB.$$

Then DC is a side of the required regular $2n$-gon. This method yields easiest construction of regular dodecagon.

III. *Solution by Nellie F. Henderson, Martins Ferry, O.*

Let AB be one side of a regular polygon of n sides, having its center at O.

Draw AD and BC $\perp$ AB at points A and B, respectively.

Draw OA and OB; then draw OE $\perp$ AB from O.

Bisect the $\angle$s AOE and BOE and extend their bisectors until they cut AD and BC at F and G, respectively.

FG will be a side of a regular polygon of $2n$ sides.

Solutions were also received from A. F. FAIRBANK, GERTRUDE BUCK, T. H. BRIGGS, *and* PHILOMATHE.—*Ed.*

553. *Proposed by W. W. Gorsline, Chicago.*

Of all possible triangles inscribed in a given segment the isosceles triangle has the maximum perimeter.

I. *Solution by Nelson L. Roray, Metuchen, N. J.*

Let c be the chord of the given segment, and a and b the variable sides of the triangle.

Then

$$a = c\frac{\sin A}{\sin C}, \quad b = c\frac{\sin B}{\sin C}.$$

$$a+b = \frac{c}{\sin C}(\sin A+\sin B)$$

$$= \frac{2c}{\sin c}\sin \tfrac{1}{2}(A+B)\cos \tfrac{1}{2}(A-B)$$

$$= a \text{ maximum when } A = B.$$

II. *Solution by Philomathe, Montreal, Canada.*

Let $\triangle ACB$ be isosceles, and ADB any other triangle. Produce AC and AD in E and F respectively, making CE = CB, and DF = DB; join EB and FB.

Angles E and F are equal, therefore points A, B, F, E are concyclic. But, because AC = CB = CE, angle ABE is right and AE is a diameter. Therefore, AE > AF, or AC + CB > AD + DB; that is, perimeter of $\triangle$ ABC is greater than perimeter of ADB.

Solutions were also received from W. W. Gonsline, Murray J. Leventhal; *an additional one from* Nelson L. Roray, *and one incorrect solution.—Ed.*

554. *Proposed by the Editor.*

Prove by a direct method that if two angle bisectors of a triangle are equal the triangle is isosceles.

[This theorem being a familiar one, a recently published solution by Dr. Artemus Martin in the *American Mathematical Monthly* attracted our attention and it is desired to make a collection of different direct methods. Send also copied methods (with references).—*Ed.*]

I. *Solution by Irvin E. Kline, Atlantic City, N. J., and by W. W. Gorsline, Chicago.*

Let ABC be the triangle in which the bisectors AD and BE are equal.

Through E draw a line EF, intersecting BC so that $\angle BEF = \angle BAD$, and through B draw a line intersecting EF so that $\angle FBE = \angle ADB$. Draw FG $\perp$ AC, and AH $\perp$ FB produced. Since $\angle$s BAD AND ADB are two $\angle$s of a $\triangle$, they are together less than two right $\angle$s and hence EF and BF will meet.

$\therefore \triangle ABD = \triangle EFB$; $\therefore$ BD = BF and AB = EF.

K is the point where bisectors AD and BE intersect.

$\angle AKB = \angle KAE + \angle AEK = \angle BEF + \angle AEK = \angle AEF$.

$\angle AKB = \angle KDB + \angle DBK = \angle FBK + \angle KBA = \angle FBA$.

$\therefore \angle AEF = \angle FBA$; $\therefore \angle FEG = \angle ABH$; $\therefore \triangle FGE = \triangle AHB$.

$\therefore$ GE = HB and GF = HA; $\therefore \triangle FGA = \triangle AHF$.

$\therefore$ GA = HF and AE = BF = BD; $\therefore \triangle ABE = \triangle BAD$.

$\therefore \angle EAB = \angle DBA$; $\therefore$ AC = BC.

Note: The above proof is taken mostly from *Loomis' Original Investigations.* Loomis also gives an indirect method of proof.—I. E. K.

II. *Solution by Nelson L. Roray, Metuchen, N. J., Irvin E. Kline, Atlantic City High School, and Murray J. Leventhal, New York City.*

The formula for the bisector of an angle is

$$t_a = \frac{2}{b+c}\sqrt{bcs(s-a)}.$$

$$t_b = \frac{2}{a+c}\sqrt{acs(s-b)}.$$

$$\therefore \quad \frac{2}{b+c}\sqrt{bcs(s-a)} = \frac{2}{a+c}\sqrt{acs(s-b)}.$$

$$\therefore \quad a = b$$

and the triangle is isosceles.

III. *Second solution by Nelson L. Roray, Metuchen, N. J.*

Let CAB be the given triangle, and the bisector of $\angle B$ intersect CA at D, of $\angle A$, CB at E.

Then

$$CD = \frac{ab}{a+c}, \quad CE = \frac{ab}{b+c}.$$

and

$$\frac{AD^2}{BD^2} = \left(\frac{ab}{a+c}\right)^2 + a^2 - \frac{2a^2b}{a+c}\cos C,$$

$$AE^2 = \left(\frac{ab}{b+c}\right)^2 + b^2 - \frac{2ab^2}{b+c}\cos C.$$

$$\therefore \quad \left(\frac{ab}{a+c}\right)^2 + a^2 - \frac{2a^2b}{a+c}\cos C = \left(\frac{ab}{b+c}\right)^2 + b^2 - \frac{2ab^2}{b+c}\cos C.$$

Whence $a = b$

and the triangle is isosceles.

IV. *Third solution by Nelson L. Roray, Metuchen, N. J.*

Let CAB be the given triangle, and the bisector of $\angle B$ intersect CA at D, of $\angle A$, CB at E.

$$\angle CDB = \angle A + \angle B/2 \qquad \angle CEA = \angle B + \angle A/2.$$

$$\frac{\sin(A+B/2)}{\sin B/2} = \frac{a}{CD}, \quad \frac{\sin(B+A/2)}{\sin A/2} = \frac{b}{CE}$$

$$\therefore \quad \frac{\sin(A+B/2)}{\sin(B+A/2)} \cdot \frac{\sin A/2}{\sin B/2} = \frac{a}{b} \cdot \frac{CE}{CD}.$$

Also,

$$\frac{\sin A/2}{\sin C} = \frac{CE}{BD} \text{ and } \frac{\sin B/2}{\sin C} = \frac{CD}{AE} \qquad \therefore \frac{\sin A/2}{\sin B/2} = \frac{CE}{CD}.$$

Hence,

$$\frac{\sin(A+B/2)}{\sin(B+A/2)} = \frac{a}{b} = \frac{\sin A}{\sin B}$$

and, as is easily proved, $\angle A = \angle B$ and the triangle is isosceles.

V. *Fourth solution by Nelson L. Roray, Metuchen, N. J.*

Let the interior bisectors of angles A and B intersect CB and AC at E and F, respectively, and each other at I, and the exterior bisectors of angles B and C at R and R′, respectively.

Let $AE = BF = m$, $IE = a$. $RE = x$, $IF = c$, and $R'F = y$. Then we have at once,

$$\frac{x}{x+m} = \frac{a}{m-a},$$

$$\frac{y}{y+m} = \frac{c}{m-c},$$

and

$(y+c)(m-c) = (x+a)(m-a)$ (since $\angle R = \angle R'$).

Eliminating m and y from these equations, we get an equation, one of whose factors is $a-c$, whence it easily follows that the triangle is isosceles.

VI. *Solution by Philomathe, Montreal, Can., and Norman Anning France.*

CD and BE bisect angles C and B respectively.

We have CD = BE = m, to prove that AB = AC or $b = c$.

Let CE = x, and BD = y.

From geometry, we know that

$$x = \frac{ab}{a+c} \text{ and } y = \frac{ac}{a+b}.$$

Also,

$m^2 = ac - x(b-x) = ab - y(c-y)$.

Hence,

$$ac - \frac{ab}{a+c}\left(b - \frac{ab}{a+c}\right) = ab - \frac{ac}{a+b}\left(c - \frac{ac}{a+b}\right)$$

or,

$$c - \frac{b^2}{a+c}\left(1 - \frac{a}{a+c}\right) = b - \frac{c^2}{a+b}\left(1 - \frac{a}{a+b}\right), \quad \text{since } a \neq 0;$$

or, after a few transformations,

$(b-c)[(a+b)^2(a+c)^2 + bc(a^2+b^2+c^2+2ab+2ac+bc)] = 0$.

Now, the factor between brackets is essentially positive, therefore $b-c = 0$, or $b = c$.

Three incorrect solutions were received.—Ed.

Trigonometry.

555. *Proposed by Daniel Kreth, Wellman, Ia.*

Determine a point P within a triangle ABC such that the angles PAB, PBC, PCA, shall be equal.

I. *Solution by Murray J. Leventhal, New York City.*

Let α be this angle. Then APB = $\pi - B$, BPC = $\pi - C$, and CPA = $\pi - A$. By the Law of Sines,

$$AP = \frac{c\sin(B-\alpha)}{\sin B} = \frac{b\sin\alpha}{\sin A} \qquad (1)$$

since

$\sin(\pi - B) = \sin B$, and $\sin(\pi - A) = \sin A$.

From (1) we obtain

$$\frac{\sin(B-\alpha)}{\sin\alpha\sin B} = \frac{b}{c\sin A} = \frac{\sin B}{\sin C\sin A} = \frac{\sin(A+C)}{\sin C\sin A}.$$

Expanding the numerators of the first and fourth ratios and dividing through by their respective denominators, we get,

$$\cot\alpha - \cot B = \cot A + \cot C$$

or,

$$\cot\alpha = \cot A + \cot B + \cot C$$

as the required relation.

II. *Construction by Irvin E. Kline, Atlantic City, N. J.*

Note: Mr. Kline appends proof of the construction but it is omitted for lack of space.—*Ed.*

Construction: Through point B erect a perpendicular to a. Through A draw a line so that it will form with c and this perpendicular an isosceles triangle. With vertex B_1 of this isosceles triangle as center and B_1 A as radius, describe a circle. Through A erect a perpendicular to c, and through C draw a line so that it will form with b and this perpendicular an isosceles triangle. With vertex A_1 of this isosceles triangle as center and A_1 C as radius, describe a circle. Likewise at C draw a perpendicular to b and construct an isosceles triangle. With C_1 as center and C_1B as radius, describe a circle. These three circles will intersect in a point P such that $\angle PAB = \angle PBC = \angle PCA$.

Another point may be found by going around the triangle in the opposite direction. These points are called *Brocard's Points.*

See Weber and Wellstein: *Encyclopadie der Elementar Mathematik,* Vol. II.

Solutions were also received from Philomathe, and Nelson L. Roray, one incorrect solution was received.—Ed.

PROBLEMS FOR SOLUTION.

Algebra.

566. *Proposed by R. T. McGregor, McArthur, Cal.*

Solve the equation

$$\sqrt[4]{x+27}+\sqrt[4]{55-x}=4.$$

Geometry.

567. *Proposed by N. P. Pandya, Sojitra, India.*

Circumscribe a triangle about a given circle, the ratio of the angle bisectors being known.

568. *Proposed by Murray J. Leventhal, Stuyvesant High School, New York City.*

The line that joins the orthocenter of a triangle to any point on the circumscribed circle bisects the line joining the feet of the perpendiculars dropped from this point upon the three sides of the triangle.

569. *Proposed by N. P. Pandya.*

The vertex A of a triangle is the center of a given circle. P and Q are points of intersection of AB, AC respectively, with the circle. The tangents at P and Q divide the base in the ratios $k : l$ and $m : n$, respectively. Construct the triangle ABC.

Trigonometry.

570. *Proposed by R. T. McGregor.*

Find θ when

$$\frac{\tan^3\theta+\sec^3\theta}{\csc\theta-\operatorname{ctn}\theta}=\frac{1}{3}.$$

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

University School, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Science Tests.

To those who have asked to be enrolled as cooperating on science tests some lists in physics have already been mailed. Chemistry will follow. Suggestions are desired. Returns will be compiled as rapidly as received and communicated to all as quickly as possible.

J. P. Drake, Emporia, Kan., and Katherine Weaver, Emma Willard School, Troy, N. Y., have asked to be added to the list of those who wish tests.

Acknowledgment.

The receipt of examination papers is acknowledged with thanks from Charles J. Pieper, University High School, Chicago, Ill.; H. E. Hammond, Kalamazoo, Mich.; Katherine Weaver, Troy, N. Y.

QUESTIONS AND PROBLEMS FOR SOLUTION.

302. *What do you think of the following test in General Science, especially Part II?*

UNIVERSITY HIGH SCHOOL, CHICAGO—SECOND SEMESTER—FEBRUARY 6, 1918.

General Science—Part I.

Answer all questions in order. Each question counts 15 points.

1. Why is a room cooled more rapidly if a window is opened at the top than when opened at the bottom? Would the change of air be more or less rapid if the window were opened at both the top and bottom? Why?
2. Explain, using a drawing if you think it will help you in the explanation, how a simple mercury barometer is made. How does it work?
3. How does yeast cause bread to rise? Explain fully.
4. How are carbohydrates made in the leaf blade, and what are four parts of the blade which take part in its manufacture?
5. Name three important gases of the air. How may one of these be made in the laboratory?
6. Tell about two experiments performed in the laboratory which prove to you that air is matter.

General Science—Part II.

There are forty blank spaces in the paragraphs that follow. To complete each statement write the proper word in the blank space. In several cases one of several words may be used. Each word correctly written counts 1–2 point.

1. Air pressure is measured by means of a ..... There are two kinds: ..... and ..... If either of these instruments is taken up in an aeroplane it will show a ..... pressure than at sea level. If carried into a deep mine it will show a ..... pressure. On a fair day the pressure is ....., while on a rainy day it is .....
2. The instrument which is used to take the temperature of the air is called ..... There are two kinds: ..... and ..... We commonly use the ..... kind on which the average temperature of a living room should be approximately ..... degrees and the normal temperature of the body is ..... degrees.
3. Air ..... when heated and ..... when cooled. Therefore warm air will ..... from the warm ground because the cold air has a ..... weight. The air is warmer in summer than in winter because the rays of the sun strike the earth more ..... in summer. Also the days are ..... in winter than in summer.
4. In a cloud from which rain is falling the ..... is ..... per cent. If the temperature is below 32 degrees F. the

water vapor will come out of the air in the form of ..... If the temperature is above 32 degrees F. the water vapor will come out in the form of ..... When the air is nearly saturated and the air is then cooled a ..... will appear.

5. Winds blow from an area of ..... to an area of ..... pressure. The velocity of the wind depends upon the ..... of the pressures. A cyclone occurs in a ..... pressure area. If the wind sets in from the south or southeast and the air pressure is decreasing a ..... is approaching from a ..... direction. A south wind from the Gulf has a ..... humidity and often brings rain because it is ..... as it comes north.

6. Of the three forms of matter the molecules are farthest apart in the ..... form. The gases in the air do not separate into layers according to their weights because they ..... An ..... is smaller than a molecule, and a molecule of water is composed of two ..... of ..... and one of .....

7. Plants which do not contain chlorophyll are called ..... plants. Of the three kinds of plants which occur in the air ..... causes milk to sour.

Please answer questions numbered 303 and 304 in the following list.

SHEFFIELD SCIENTIFIC SCHOOL—SEMI-ANNUAL EXAMINATION—JUNIOR CLASS—JANUARY 29, 1918.

Physics—Engineering Science Group.

1. (*a*) Find the torque acting on a bar magnet when placed in any position in a magnetic field.

303. (*b*) Find the magnetic intensity on the prolongation of the axis of a bar magnet 30 cm. from one of the poles, the strength of each pole being 1200 units and the distance between the two poles being 20 cm.

2. (*a*) Derive an expression for the potential at a point due to a charge of electricity at some distance.

(*b*) Find the potential at the center of a square 10 cm. on a side, due to charges of $+50$, $+100$, -150, and $+200$ units placed at the middle points of the sides of the square.

(*c*) Find the electrical energy of a sphere of radius 10 cm. when charged with 200 units of electricity.

3. (*a*) Give a rule for telling the direction of the magnetic field about a current.

(*b*) Obtain a value for the magnitude of the magnetic field inside of a solenoid.

4. (*a*) What are the essential features of a voltmeter; of an ammeter?

(*b*) A galvanometer of 20 ohms resistance gives a deflection of 50 divisions for a current of 1 milliampere. How should the instrument be modified to serve as an ammeter with one division per ampere?

5. Define, isogonic line, electrostatic capacity, electromagnetic unit of quantity, neutral temperature for a thermo-electric couple, a henry.

6. Two cells each having an E. M. F. of 1.6 volts and an internal resistance of .4 ohm are connected in parallel and joined to two resistance coils of .2 and .3 ohm respectively, which are also connected in parallel. What is the current in the .3 ohm coil and what is the drop of potential between its ends? How much heat is generated in this coil per minute?

7. (*a*) Define magnetic induction; magnetic flux; magnetic permeability.

(*b*) What is the character of the relation between the magnetic induction in iron and the magnetizing field?

8. (*a*) Obtain an expression for the electromotive force in a circular coil of wire rotating in a uniform magnetic field.

304. (*b*) What is the maximum E. M. F. in such a coil of 50 turns having a diameter of 40 cm. when this rotates 1200 times per minute about an axis perpendicular to a field of 300 units?

9. (*a*) Give Fleming's rule for the direction of the force acting on a conductor when placed in a magnetic field.

(*b*) Find the force per unit length in a conductor carrying 20 amperes whose length is parallel to the direction of a magnetic field of .3 unit.

(*c*) What is the nature of the interaction between two parallel conductors carrying currents?

10. (*a*) Explain the theory of ionization by collision, and tell how it accounts for a spark discharge.

(*b*) What are radioactive substances?

(*c*) State the main facts about each of the different kinds of rays given off by radioactive substances.

SOLUTIONS AND ANSWERS.

Apropos of the answers to question No. 284 in the March issue.
By H. E. Hammond, Central High School, Kalamazoo, Mich.

Messrs. Smith and Drake both are in favor of having all the laboratory notes made in the laboratory. The problem is not one to be dismissed in a few words, but depends largely on the time for laboratory work that is available. In many small schools this is the same as a class period, forty-five minutes, and elsewhere it runs up to three hours, 180 minutes. We have seventy-five minutes, and it is difficult to get it more than once a week. Manifestly, all this time must be used to get the first draft of the results, but we use a carbon copy book for rough work, and the duplicate is left at the end of the period. The complete write-up *has* to come later. All possible efforts have been made to allow the pupils to have every minute of the seventy-five for actual work, and the large majority can finish the usual amount of work in that time, though seldom can more than four trials be taken, and often only two. Are many trials necessary or desirable in high school? The writer would like to hear from others who have the same problem to meet.

Second-Year Physics. Comment by W. A. Zinzow, Wausau, Wis.

I have but recently become a very much interested reader of SCHOOL SCIENCE AND MATHEMATICS, and particularly of the "Science Questions Department."

I have been in charge of the Physics Department of the Wausau High School during the past three years. This year I have introduced, with the cooperation of the Board of Education and our Superintendent and Principal, a second year's work in physics in the form of a year's course in electricity. In my regular physics work I am giving the usual amount of time to the study of electricity, but during the second year we are taking up the subject in a more intensive manner.

During the past semester we reviewed some of the fundamental principles of electricity, going into details a little more than usual. After that we spent about six weeks on measurements, such as Ohm's Law problems in their various forms, measurements of resistance and power. We devoted the last six weeks of the semester to a somewhat comparative study of storage batteries. I am enclosing a copy of the examination questions that the class worked on at the end of the semester.

During the present semester we are studying the theory of direct and alternating current generators, laying special stress on *why* certain actions result, rather than their mathematical relations. Up to the present time we have been using Millikan-Crocker-Mills *Practical Lessons in Electricity* and Evans *Manual of Electricity* as textbooks, together with Archbold *A Laboratory Course in Practical Electricity* as a laboratory outline. From now on for about six weeks the class is going to spend its laboratory periods in the various electric shops about town under the supervision of the men in charge of the shops. After that brief period of training is over they will go out individually with the workmen from the various shops as helpers for wiremen, electric instrument testing, telephone work, etc. In this way these boys will be able to fill the places of men who will be drawn in the next draft, in addition to making their course to a certain extent practical rather than purely theoretical.

I have a class of twelve boys, and every one of them has been at work with all kinds of spirit, and I believe they are getting a great deal out of it.

RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge.

State University of Iowa, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be nontechnical and it is hoped that they will furnish material which will be of value in the classroom. Suggestions and contributions should be sent to H. L. Dodge, Department of Physics, State University of Iowa, Iowa City, Iowa.

The Quantum Theory and Molecular Structure.

By Robert C. Colwell, Geneva College, Beaver Falls, Pa.

The inability of the classical mechanics to explain the spectra of the elements is at once apparent if we fix our attention upon the hydrogen spectrum. The atom of this element consists of a single electron rotating about a central nucleus. Under the inverse square law, its energy should be gradually expended in radiation, and the molecule should eventually reach a state in which no radiation will take place. Then, too, it seems impossible for a single rotating electron to give the complicated line spectrum of hydrogen. Bohr, however, has shown how a modification of the quantum theory will account for all the lines of the hydrogen spectrum. In this theory, he supposes that the electron may rotate about the central nucleus in a series of rings, and that the electron jumps at once from one ring to the other without revolving in the intermediate orbits. The development of this theory depends upon two very simple theorems in elementary physics.

First: When a body is moving uniformly in a circle, the centripetal force is given by the equation:

$$F = \frac{mv^2}{r} \qquad (1)$$

in which v is the velocity of the body of mass m, and r the radius of the circle.

Second: The potential energy of an electron e at a distance r from a nucleus E is given by the equation:

$$\text{P. E.} = \frac{Ee}{r} \qquad (2)$$

in which E and e denote the charges of the nucleus and the electron respectively.

Suppose the electron revolves in its orbit n times per second. Then, since r is the radius, the

$$\text{velocity } v = 2\pi nr \qquad (3)$$

Under the Newtonian Law, the force of attraction between the nucleus and the electron is

$$F = \frac{Ee}{r^2} \qquad (4)$$

If there is equilibrium this force is equal to the centripetal force. Thus from (1) and (4)

$$F = \frac{mv^2}{r} = \frac{Ee}{r^2} \qquad (5)$$

The potential energy of the electron becomes, from (2), (3), and (5)

$$\text{P. E.} = \frac{Ee}{r} = 4\pi^2 mn^2 r^2 \qquad (6)$$

The kinetic energy of the electron is,

$$\text{K. E.} = \tfrac{1}{2}mv^2 \tag{7}$$

$$= \tfrac{1}{2}\frac{\text{E}e}{r} \tag{8}$$

The work required to move the electron from its orbit to a position of *rest* at infinity is

$$\text{P. E.} - \text{K. E.} = \frac{\text{E}e}{r} - \tfrac{1}{2}\frac{\text{E}e}{r} = \tfrac{1}{2}\frac{\text{E}e}{r} \tag{9}$$

Let us call this amount of energy W. Now let us assume that W does not vary continuously but only by definite increments, such that

$$\text{W} = \tfrac{1}{2}\text{T}hn \tag{10}$$

in which T is a positive interger, h the Planck constant, and n the number of revolutions per second.

When the electron is moving in a circle of radius r_1, corresponding to a value of $\text{T} = \text{T}_1$, from (6) and (10),

$$\text{W}_1 = \tfrac{1}{2}h\text{T}_1 n = \tfrac{1}{2}h\text{T}_1\frac{\sqrt{\text{E}e}}{2\pi\sqrt{mr^3}} \tag{11}$$

Substituting the value of r_1 from (9),

$$\text{W}_1 = \frac{2\pi^2 m\text{E}^2e^2}{\text{T}_1^2h^2} \tag{12}$$

If the electron is moving in another circle of radius r_2,

$$\text{W}_2 = \frac{2\pi^2 m\text{E}^2e^2}{\text{T}_2^2h^2} \tag{13}$$

Bohr assumes that the difference in energy between (12) and (13) is given out as a monochrometic radiation as the electron jumps from radius a_1 to radius a_2.

Then

$$h\nu = \text{W}_1 - \text{W}_2 = \frac{2\pi^2 m\text{E}^2e^2}{h^2}\left(\frac{1}{\text{T}_1^2} - \frac{1}{\text{T}_2^2}\right) \tag{14}$$

Equation (14) is Bohr's equation for the spectral lines. If, as in hydrogen, $\text{E} = e$,

$$\nu = \frac{2\pi^2 me^4}{h^3}\left(\frac{1}{\text{T}_1^2} - \frac{1}{\text{T}_2^2}\right) \tag{15}$$

If $\text{T}_1 = 1$ and $\text{T}_2 = 1, 2, 3, \ldots\ldots n$ in succession, the frequencies calculated from equation (15) are exactly the frequencies observed in one of the series of lines in the hydrogen spectrum. If $\text{T}_1 = 2$, another series is given, and so forth. Three of these series, the Balmer, Lyman, and Paschen series, have been observed.

THRIFT STAMPS.

It is pointed out by the Treasury Department that Thrift Stamps are not made redeemable in cash for the reason that these stamps are simply intended as a convenient method for the small savers to accumulate enough to purchase War Savings Stamps, which bear interest and are redeemable in cash.

In addition, to provide for redemption for these Thrift Stamps would involve such an amount of detailed accounting and labor and expense as to impair the practicability of their use. In fact, they would be more trouble and expense to the Government possibly than they are worth.

ARTICLES IN CURRENT PERIODICALS.

American Journal of Botany, for February; *Brooklyn Botanic Garden, Brooklyn, N. Y.; $5.00 per year, 60 cents a copy:* "The Structure of the Uredinium in Pucciniastrum Agrimoniae," C. A. Ludwig and C. C. Rees; "Spore Formation in Philocopra Coeruleotecta," Hally Jolivette Sax; "Selected Cycles in Gymnoconia Peckiana," George F. Atkinson; "Aspergillus Fumigatus, A. Nidulans, A. Terreus N. Sp., and Their Allies," Charles Thom and Margaret B. Church.

American Mathematical Monthly, for March; *27 King St., Oberlin, Ohio; $3.00 per year:* "Rabbi Ben Ezra and the Hindu-Arabic Problem," D. E. Smith and J. Ginsburg; "The Theory of Similar Figures," Roger A. Johnson; "Note on a Certain Class of Determinants," W. H. Metzler.

Geographical Review, for March; *Broadway at 156th St., New York City; $5.00 per year, 50 cents a copy:* "Polynesian Navigators: Their Exploration and Settlement of the Pacific," Elsdon Best; "Notes on MacMillan's Ellesmere Island Trip," (twelve photos); "Modern Iceland" (five photos), Godmunder Kamban; "Some Interesting Geographical Problems in the Exploration of Northern Canada" (two photos), Charles Camsell; "The Racial History of the British People," (two maps), H. J. Fleure.

Journal of Geography, for April; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Montana," Grant E. Finch; "The Weather Factor in the Great War: VIII," Robert De C. Ward; "Geography Made Real by Field Study," Jennie Hall; "Some Results of the Location of Australia," S. S. Visher; "The Origin of Petroleum Pools," Edward Steidtmann.

Popular Astronomy, for April; *Northfield, Minn.; $3.50 per year:* "An Account of the Rise of Navigation," R. H. Curtiss; "What Was the Star of Bethlehem?" (continued), Stansbury Hagar; "The Zenith Equatorial," William H. Pickering; "Daylight Seeing," William H. Pickering; "In Fickle April's Firmament," Charles Nevers Holmes; "Hubble's Variable Nebula in Monoceros" (with Plate XI), C. O. Lampland.

Physical Review, for March; *Ithaca, N. Y.; $6.00 per year, 60 cents a copy:* "The Magnetization of Iron in the Absence of Hysteresis," Winthrop R. Wright; "The Ionization Potential of Mercury Vapor," T. C. Hebb; "On Equilibrium under Non-Hydrostatic Stress," P. W. Bridgman; "Elasticity of Impact of Electrons with Gas Molecules," J. M. Benade and K. T. Compton; "The Use of Mercury Droplets in Millikan's Experiment," John B. Derieux; "The Optical Properties of Rubidium," J. B. Nathanson; "The Theory of Ionization by Collision. IV. Cases of Elastic and Partially Elastic Impact," K. T. Compton and J. M. Benade.

Popular Science Monthly, for April, *225 West Thirty-Ninth St., New York City; $1.50 per year:* "The Eyes in the Air," Henry Bruno; "Submersible Forts to Protect Our Coasts;" "Hiding Ships with Paint," Robert G. Skerrett; "Dropping Death from the Skies," Carl Dienitbach; "King Weather Rules the World"; "Our Annual Coal Drama," Lloyd E. Darling; "Dealing Death with Depth Bombs," Lloyd E. Darling.

Psychological Clinic, for March; *Woodland Ave. and Thirty-Sixth St., Philadelphia; $1.50 per year, 15 cents a copy:* "Preliminary Impressions of the Stanford Revision of the Binet-Simon Scale," J. E. Wallace Wallin; "A Study of One Hundred Retarded Fourth-Grade Pupils Tested by the Binet Scale," William I. Lacy.

School Review, for March; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "The Need of a Constructive Social Program for the High School," Olivia Pound; "High School Observation Work," C. O. Davis; "The Correlation of the Professional Training with the Teaching Success of Normal School Graduates," Floyd E. Moody; "The Need of Broad-Guage Courses in Geography," R. H. Whitbeck.

School World, for March; *Macmillan Company, London, Eng.; 7s. 6d. per year:* "The Arithmetic of Citizenship," T. Percy Nunn; "Descriptive Astronomy in 'Science For All' Classes," Rev. A. L. Cortie; "Geographical Aspects of the Channel Tunnel," Francis Fox.

DESTROY THE BARBERRY.

The common barberry is a menace to cereal crops in that it harbors one stage of the black stem rust. This rust is estimated to have caused a loss of $205,000,000 in this country in 1916. Secretary of Agriculture Houston has requested each state governor to do everything possible to reduce this loss by spreading information concerning the relation between the barberry and wheat rust. While the total eradication of the barberry would not entirely eliminate the rust of cereals, there is no question that such a measure would greatly reduce the rust. A commission for aiding in the dissemination of knowledge concerning the part the barberry plays in increasing the loss from rust has been organized in Illinois. It is also its purpose to urge all patriotic citizens to destroy the common barberry on their lands. This is especially important in the region north of Kankakee. The value of the barberry is so insignificant compared with the great food value of our cereal crops that no one should hesitate to make this sacrifice. In Denmark, where the barberry was outlawed a number of years ago, there has been a decided decrease in the amount of rust.

The Japanese barberry does not harbor the rust. This species may be distinguished from the European or common barberry as follows:

Japanese Barberry	Common (European) Barberry
(Does not harbor rust)	(Harbors rust)
Edge of leaf smooth.	Edge of leaf saw-toothed.
Twigs of last year reddish-brown.	Twigs of last year dun or grey.
Berries single or rarely in groups of two or three.	Berries in a cluster on one main stem.

EXPLOITATION OF NEGLECTED AQUATIC RESOURCES.

The history of the establishment of the tilefish fishery is well known. Up to the end of the fiscal year 1916, when the fishery was only eight months old, there had been caught and sold over 4,388,000 pounds of tilefish, for which the fishermen received more than $210,000. By the end of the first twelve months, the catch was upward of 10,250,000 pounds, selling for more than $400,000. During the fiscal year 1917, the landings aggregated 11,641,500 pounds, and the receipts of the fishermen exceeded $477,000. The headquarters of the fishery are New York and Boston.

The campaign to make an asset out of a confirmed nuisance in the form of the grayfish has progressed rapidly, and on the whole satisfactorily. Difficulties in the way of making this fish available and acceptable as human food have been overcome, and there is now an established industry on both Atlantic and Pacific coasts in canning, salting, and smoking grayfish.

Other more or less neglected fishes whose utilization has been advocated and otherwise aided by the Bureau are the sablefish of the northwest coast, burbot of the Great Lakes, and bowfin of the interior waters generally.

The scarcity of mammal hides for use in making leather has brought into prominence the value for this purpose of the skins of sharks and other aquatic creatures. Through the activities of the Bureau in behalf of fishermen and tanners, a market for such skins has been developed, and leather of a very good grade for certain industrial uses is now being made from this hitherto neglected source of supply. The general utilization of sharks for their meat and skins will have the effect of increasing the abundance of other fishes by reducing the numbers of their most destructive enemies.

Propagation of Food Fishes.

The year's work in fish culture was attended with conspicuous success.

The output of the hatcheries was larger than in any previous year, and for the first time passed the five billion mark. There were operated fifty-five regularly established hatcheries, nineteen subhatcheries, and seventy-four egg-collecting stations. Increased efficiency and the larger volume of work reduced the unit cost of operations to the lowest point so far attained, namely, $114 per million fish produced and planted, this amount covering all overhead charges, including salaries of administrative and clerical force in Washington.

Large quantities of fish eggs were donated to the various state fish commissions for hatching and planting under local auspices.

The distribution of the hatchery output by special fish cars and detached messengers required 138,717 miles of railroad travel by cars, and 645,721 miles of railroad travel by messengers carrying fish in baggage cars. The fish were distributed to waters in every state and Alaska.

FRESH-WATER MUSSEL PROPAGATION.

With headquarters at Fairport, Iowa, on the Mississippi River, extensive work has been conducted in the Mississippi and tributaries, addressed to the pearly mussels which support a very extensive button industry. In this fascinating branch of the Bureau's work, larval mussels are inoculated on the common fishes of the region, and the fishes are then liberated in open waters. After a time the young mussels drop off the fishes and begin their independent existence on the bottom. Buttons have been made from mussels grown from the microscopic larvae to full-sized adults in the ponds of the fishery laboratory at Fairport.

ANTIFREEZING SOLUTIONS FOR AUTOMOBILE RADIATORS.

The subject of antifreezing solutions for automobile radiators has been brought very forcibly to the attention of users of motor vehicles this winter, and many requests for information regarding their use have been received by the Bureau of Standards, Department of Commerce. An investigation was undertaken by the Bureau to establish the value of these compounds, and sufficient data have recently been obtained to justify a preliminary statement. This work will be continued, tests equivalent to service conditions will be made, and a more comprehensive report given at a later date, but in time for use during the coming winter.

A careful study of this question by the Bureau leads to the conclusions based on experiment that, (1) calcium chloride compounds should be used with caution, if at all, on account of their corrosive action; (2) kerosene or similar oils should not be used on account of their inflammability, high boiling point, and effect on rubber; (3) mixtures of glycerine and alcohol can be used, but the price of glycerine and the need for it in the manufacture of munitions at the present time should preclude its use; (4) solutions made from either wood alcohol or denatured alcohol seem at the present time to be the most desirable antifreezing solutions to use. If the wood alcohol is free from acid there is little choice between the two alcohols. Wood alcohol costs more than denatured alcohol and is more volatile, but its lower freezing point allows a less amount to be used, which may counteract the above disadvantage.

The ideal antifreezing compound is one that will prevent freezing of the radiator liquid without injuring either engine or radiator, that will not lose its non-freezing properties after continued use, and that does not materially change the boiling point of water when dissolved in it.

KINDS OF ANTIFREEZING COMPOUNDS.

There are two general types of these compounds—one a solution in water of alcohol or glycerine, or of a mixture of the latter two, the other a solution in water of calcium chloride or the dry salt itself, which con-

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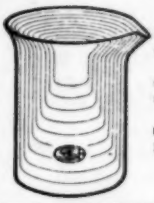

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The Bureau of Chemistry has made considerable progress in demonstrating the processes devised by it for preparing sugar-cane and sorghum sirup that will not crystallize or ferment, and for utilizing the by-products. The work already under way on methods of handling, packing, storing, shipping, and utilizing fish in order to make the supply more immediately available for food, has been extended and developed. In connection with the efforts to increase the supply of poultry and eggs, plans have been made to stimulate the establishment of poultry and egg packing plants in accordance with the principles worked out by the Food Research Laboratory. Ten additional men are being assigned to this work.

tains sometimes small amounts of other substances such as salt, sal ammoniac, sugar, or syrup. Kerosene and similar oils, without admixture, are sometimes used.

Kerosene.

Kerosene has a lower freezing point and higher boiling point than water, but the inflammability of its vapor makes it dangerous to use, and its high and uncertain boiling point might lead to the serious overheating of the engine, or even to the melting of the solder in the radiator. It has a marked solvent action on rubber parts. These facts would seem to clearly indicate that this material should not be used.

Alcohol and Calcium Chloride.

The alcohol-water type is the most common, and is not generally sold under any trade name, but recently there have appeared on the market a number of antifreezing compounds of the calcium chloride type. These compounds are sold under a variety of names, and startling claims are made for their effectiveness and lack of injurious effects.

Corrosive Action. The alcohol solutions do not exert a greater corrosive action than water alone. This can be predicted from theoretical considerations and is well established in practice. However, wood alcohol sometimes contains free acid, such as acetic acid, which is objectionable, and for this reason wood alcohol should be used only when it is known to be free from acids.

The calcium chloride compounds exert a greater corrosive action than water on the engine jacket, on the solder in the radiator, and on aluminum which is sometimes used in manifolds, pumps, and headers. The effect on engine jackets may be neglected since these are generally sufficiently heavy to permit considerable corrosion without being weakened. The effect on soldered joints may be serious, since tests made at the Bureau of Standards have shown the complete removal of solder from copper and brass when immersed in a hot twenty per cent calcium chloride solution for four days. A number of such tests were made, and there was always a more rapid corrosion or eating away of solder in these antifreezing compounds than in water.

Calcium Chloride and Ignition. Another troublesome effect of calcium chloride solutions is experienced if small leaks occur in the radiator, the water jackets, or connections, and the solution comes in contact with the spark plugs and ignition wires. In some cases the drops of the solution may be carried back on the engine in a more or less atomized state, assisted by the fan when running. The salt deposited when the water evaporates is very difficult to remove, and when it cools absorbs water and becomes a good electrical conductor, short-circuiting the spark plugs and sometimes making it impossible to start the engine. The difficulty may disappear when the engine is heated up.

There are also certain conditions in the manufacture of calcium chloride which may result in a compound that will deposit large crystals in the radiator as the solution cools; this may prevent effective circulation.

Calcium Chloride Has Been Used. Regardless of these objections, reports have been received to the effect that calcium chloride solutions have been used a number of years in the same radiator without producing apparent corrosion. Nevertheless, such solutions cannot be recommended as safe, and they should not be used if there is any aluminum in the cooling system.

The chief advantage of calcium chloride compounds is that they are not volatile. The solutions can be kept practically uniform by adding water from time to time. Unfortunately, this is not true with the alcohol solutions, because the alcohol continually boils out and it must be re-

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Wm. S. Franklin of Mass. Inst. of Technology, and
Barry MacNutt of Lehigh University.

Bacon long ago mentioned the need of "A Calendar of Leading Experiments for the better interpretation of nature," and the authors have borrowed from Bacon the title of this book *On Lecture-room Experiments in Physics.*

Most of the experiments as described are very simple and most of the apparatus required is inexpensive, and the authors believe that the book will be very helpful to the teacher of physics in the High School.

An important feature of the book is an Appendix on *A Visitors' Laboratory of Physics* in which suggestions are made for the setting up permanently of about 80 experiments for the edification of visitors. The authors believe that this phase of the museum idea should be developed in every High School.

Another feature of the book is an extremely simple and clear setting forth of the fundamental ideas of mechanics; and the authors make use of every opportunity to illuminate the problems of the teacher, and they do this in a way that will certainly entertain the reader and, as the authors believe, also edify him.

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placed frequently in order to maintain the proper proportion of alcohol. Glycerine is frequently substituted for part of the alcohol to reduce evaporation, but when glycerine is used the rubber connections may be affected somewhat seriously, depending on the quality of the rubber. The most practical method to maintian the proper quantity of alcohol in the solution is to determine the specific gravity of the liquid by means of a hydrometer and by reference to a table add the necessary quantity of alcohol to obtain the desired gravity.

This table and a statement regarding the use of a hydrometer can be obtained by application to the Director, Bureau of Standards, Washington, D. C.

PRICE OF COMPOUNDS. The price of these compounds is of decided interest. The retail price of denatured alcohol is more or less definitely fixed by its cost of production and the prevailing market conditions. Calcium chloride is a by-product from certain manufacturing industries, and is sold at less than two cents per pound, wholesale. However, when properly packed and labeled it is sold to automobile users as an antifreezing compound at the rate of twenty-five to fifty cents per pound, an increase of between one thousand to two thousand per cent.

Without approving the use of a calcium chloride solution as an antifreezing solution, it may be said that a homemade solution of calcium chloride can be prepared at a cost less than one-half the retail price at which such antifreezing compounds are sold, by buying calcium chloride in the open market and dissolving it in water.

CANNEL COAL.

Cannel coal has long been a will-o'-the-wisp to coal men, and to many of them its mere mention brings up visions of wealth. The reason becomes obvious when its price on the market is compared with that of ordinary bituminous coal, for in days past cannel coal has sold in the New York market at a price about three times that of the best bituminous coal and perhaps double the price of anthracite. This high price is due to old causes—strong demand and weak supply.

As a coal for use in office and household grates, as an enricher of coal gas, and as a quick-firing coal for use in fire engines and otherwise, cannel coal has filled a unique place; and these uses coupled with its scarcity in the earth have made it an object of much search and of many disappointments, because wherever it is found there has usually proved to be very little of it.

Of late years, however, fewer grates are used in the office and the home, and water gas, enriched with oil, has replaced the old type of coal gas, so that when the European war broke out the demand for cannel coal as such had largely disappeared. Then some people remembered that many years ago, before oil was struck in the country, houses were lighted with oil obtained from cannel coal. They remembered that on distillation cannel coal yielded more oil and gas than could be obtained from ordinary bituminous coal. They realized that the sudden demand for high explosives for use in the war required the utilization of the by-products formed in the distillation of coal, and they argued that if cannel coal when distilled yielded more oil and gas than other coals it should be very rich in the by-products from which benzene, toluol, and other explosive bases are made, so a demand was made for information about cannel coal. To supply this information the Government, through the Geological Survey, Department of the Interior, has just issued a report on the cannel coals of the United States, describing cannel coal in detail and telling where it can be found. This report refers to every place where cannel coal has been

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found or where it is said to occur. It contains references to nearly a hundred and fifty such places in one state alone, Kentucky.

The fact that cannel coal does yield large quantities of oil and gas is confirmed, but it is found that this oil, though suitable for ordinary burning, distills at a temperature so low that the percentage of gasoline, benzene, and other desired substances it contains is very small, and until some way has been discovered of distilling it at a higher temperature or of cracking or otherwise converting the oils found into the oils desired, the distillation of cannel coal will not furnish the large supply of gasoline, benzene, toluol, and other substances that are now so greatly needed.—[*U. S. Geological Survey Press Bulletin.*

A SUGGESTIVE APPROACH TO THE USE OF THE FUNCTIONAL NOTATION.

By L. E. Lunn,
Heron Lake, Minn.

In some of our newer texts there is an acknowledgment of the generally felt want for an earlier introduction to the notion of a function. This is rightly so as the use of the functional notation is one of the stumbling-blocks of the freshman in the collegiate courses in mathematics. The idea of function is the next great mathematical advance that the student makes after grasping the idea of general number.

In using Mr. Breslich's *Third Year of Mathematics*, I have been struck with the idea of using the functional idea in the solution of certain types of quadratic equations.

For instance, we have equations of the following nature:

1. $(x+3)^2-5(x+3)-24 = 0.$
2. $x^2+5x-3+8(x^2+5x-3)^{\frac{1}{2}} = 15.$
3. $\tan^2 y+3\tan y = 4.$

These equations are all conveniently written,

1. $f^2(x)-5f(x)-24 = 0.$
2. $f^2(x)+8f(x)-15 = 0.$
3. $f^2(y)+3f(y)-4 = 0.$

These are then solved for the function involved by rules of quadratic equations, and the function finally solved for the particular variable.

Of course these equations are readily handled by either mentally or actually making a literal substitution for the function involved. However, I believe that the above method is valuable to accustom students to the use of this form of notation.

COAST AND GEODETIC SURVEY ESTABLISHES SUBOFFICE AT BOSTON.

To keep more directly in touch with the interests of shipping in the waters of Maine, New Hampshire, and Massachusetts, the United States Coast and Geodetic Survey, Department of Commerce, will establish a suboffice in the Customhouse at Boston about January 1, 1918. As inspector in charge of this office, Homer P. Ritter, a commissioned officer of the Survey, will be prepared to furnish information relative to the operations of this branch of the Government service.

It will be the endeavor of this suboffice to cooperate fully with steamship lines, yacht clubs, mariners, and others to the extent that dangers discovered, changes in channels, and various other kinds of information needed by the Survey for keeping its nautical publications up to date shall be made available to the public as promptly as possible.

A complete and up-to-date file of charts and publications relating to our coasts and surveys will be available for inspection by those interested, and the office will maintain a supply of the charts and other publications of the Survey for sale at catalogue prices.

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BOOK REVIEWS.

A Laboratory Manual of General Chemistry, by William J. Hale, Associate Professor of General Chemistry in the University of Michigan. First edition. Pages xi+474. 2 1/2x13 1/2x19 1/2 cm. A few line drawings in the first part of the book. Cloth. 1917. $1.50. The Macmillan Company, New York.

This new laboratory manual is evidently intended for use with college classes in general chemistry. It presents in unusually complete and detailed form the essential parts of a well-rounded course in general chemistry. In the treatment of the metals the author makes an especial effort to present the chemistry that is later to be made use of (in formal qualitative analysis). The work thus given leads to an understanding of the methods of group separation, but does not attempt the detailed separation of the metals of the several groups. This correlation of the chemistry of the metals with that of qualitative analysis is admirable teaching. The book also contains a special chapter on the identification of negative radicals. Although regularly bound, the book has all right-hand pages left blank except that numbers are printed upon the otherwise blank pages to serve as a guide in the answering of numbered questions which accompany the directions. The object of this arrangement, according to the author, is to prevent the jotting down of helter-skelter notes.

The directions are terse, yet sufficiently complete and clear for the student of college age. F. B. W.

An Elementary Study of Chemistry, by William McPherson and William Edwards Henderson, Professors of Chemistry, Ohio State University. Second revised edition. Pages xii+576. 3x14x19 1/2 cm. Illustrated. Cloth. 1917. $1.60. Ginn & Company.

This revised edition of a text that has been well and favorably known to many teachers, brings it down to date and embodies some changes which have resulted from trials of the manuscript in actual use with classes. The illustrations are excellent. The ground covered is extensive, as the 576 pages suggest. The authors include elementary treatment of the mass law, and very complete elementary use of the theory of electrolytic dissociation. While the teaching of the principles is made the chief end of the text, there are many practical applications given as illustrations, and these add interest to the book. F. B. W.

The Cadet Manual, Official Handbook for High School Volunteers of the United States, by Major E. Z. Steever and Major J. L. Frink. 15×20 cm. Pages xxxi+317. Net, $1.50. 1918. J. B. Lippencott Co., Philadelphia.

The Cadet Manual is the outgrowth of several years' experience in training high school boys in Wyoming, Chicago, Washington, Kansas City, and elsewhere. In Wyoming Major Steever originated and successfully developed a course of high school military training that won the confidence and support of the entire state. The success of his work in Wyoming became so well known that he was asked by several of the large cities to initiate such a course of military training in their high schools.

This book appears at a most opportune time as it is now very evident that the only salvation of our country in the future is universal military training.

The Cadet Manual provides every aid to the introduction and successful administration of this training. All the details have been carefully worked out in actual practice. It will produce better managed schools and better communities of young men. Its sole aim is better citizenship. With the approval of the Government and the War Department, every high school in the United States should take up the Steever plan, and lay the one safe foundation for the national defense of our great democracy. *The Cadet Manual* is indispensable to this work. C. M. T.